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MANUAL OF ANATOMY

SYSTEMATIC AND PRACTICAL, INCLUDING EMBRYOLOGY

BY

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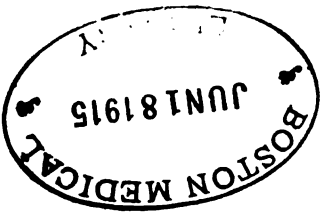

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THE HEAD AND NECK

BACK OF THE SCALP AND NECK

Landmarks.—The external occipital protuberance can, as a rule, readily be made out, and the superior curved line, if well developed, may be felt extending outwards from it. The mastoid process of the temporal bone can be distinguished without difficulty behind the auricle. The occipital artery, with the great occipital nerve on its inner side, lies a little internal to the centre of a line connecting the external occipital protuberance and the tip of the mastoid process. The occipital lymphatic gland, or glands, may be felt, when enlarged, over the upper part of the trapezius or complexus muscle. The spine of the seventh cervical vertebra, or vertebra prominens, can easily be felt, and that of the sixth may also be made out. Extending from the external occipital protuberance to the seventh cervical spine there is an elongated depression, called the **nuchal furrow,** which indicates the position of the ligamentum nuchæ. It is possible to feel the strong bifid spine of the axis by sinking the finger deeply into the upper part of the nuchal furrow, near the occipital bone, but the spines of the third, fourth, and fifth cervical vertebræ lie too deeply for detection. The lymphatic glands, known as the **glandulæ concatenatæ,** may be felt, when enlarged, along the posterior border of the sterno-cleido-mastoid muscle.

Back of the Neck—Fasciæ.—The superficial fascia presents nothing worthy of note. The deep fascia closely invests the cervical portion of the trapezius, and is then prolonged over the posterior triangle of the neck to the posterior border of the sterno-cleido-mastoid, where it divides to ensheathe that muscle. It will be described in connection with the deep cervical fascia.

Nerves.—The nerves of this region are as follows: the great occipital; the least or third occipital; the internal branches of the posterior primary divisions of the third, fourth, and fifth cervical spinal nerves; the small occipital; the great auricular; the superficial cervical; the spinal accessory; and the descending superficial branches of the cervical plexus, namely, the suprasternal, supra-clavicular, and supra-acromial.

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The **great occipital nerve** is the internal branch of the posterior primary division of the second cervical nerve. It pierces the upper part of the complexus muscle, and sometimes the trapezius, about ½ inch from the middle line. It then turns upwards, with an inclination outwards, and accompanies the occipital artery to the cranial integument, lying on the inner side of that vessel. Its branches are long, and have an extensive distribution, reaching as far as the vertex of the skull. Externally it communicates with the small occipital nerve, and internally with the least occipital.

The **least** or **third occipital nerve** is a small offset from the internal branch of the posterior primary division of the third cervical nerve. Having pierced the trapezius, it ascends internal to the great occipital nerve, with which it communicates, and has a limited distribution to the occipital integument inside that nerve.

The **internal branches of the posterior primary divisions of the third, fourth, and fifth cervical nerves** appear through the trapezius close to the middle line, and turn outwards to supply the skin of the back of the neck, that of the third furnishing, as just stated, the least occipital nerve.

The **small occipital nerve** is one of the ascending superficial branches of the cervical plexus, and arises from the anterior primary division of the second cervical nerve, sometimes receiving a branch from that of the third. It appears at the posterior border of the sterno-cleido-mastoid muscle, and ascends along that border to the occipital region. Here it divides into mastoid and occipital branches, which supply the skin of the mastoid, outer part of the occipital, and adjacent portion of the parietal, regions. It furnishes an auricular branch to the skin of the inner surface of the auricle, and it communicates with the great occipital, the mastoid and auricular branches of the great auricular, and the posterior auricular branch of the facial. The small occipital nerve is sometimes double, and in these cases one portion of it usually pierces the anterior border of the trapezius.

The **great auricular nerve,** like the small occipital, is one of the ascending superficial branches of the cervical plexus, and arises by two roots from the anterior primary divisions of the second and third cervical nerves. It turns round the posterior border of the sterno-cleido-mastoid immediately below the small occipital nerve, and passes upwards and forwards upon that muscle towards the lobule of the auricle, on approaching which it divides into mastoid, auricular, and facial branches. The *mastoid branch* is distributed to the skin over the mastoid region; the *auricular branch* supplies the skin of the inner surface of the auricle, and sends one or two twigs through the cartilage of the auricle to the skin covering its outer surface; and the *facial branch* is distributed to the skin over the parotid gland. The mastoid and auricular branches communicate with the small occipital and posterior auricular nerves, and the facial branch communicates in the parotid gland with the cervico-facial division of the facial nerve.

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The **superficial** or **transverse cervical nerve,** like the small occipital and great auricular, is a superficial branch of the cervical plexus, and arises by two roots from the anterior primary divisions of the second and third cervical nerves. It appears at the posterior border of the sterno-cleido-mastoid, close below the great auricular,

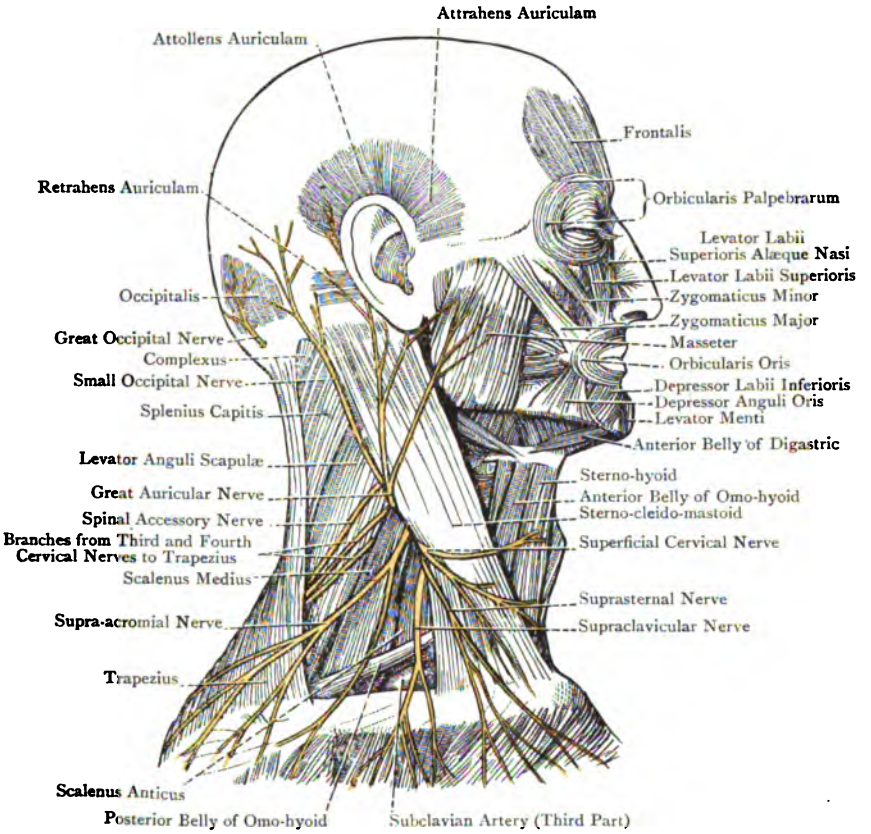

FIG. 418.—THE RIGHT SIDE OF THE HEAD AND NECK.

(The Platysma Myoides has been removed, and the Nerves are shown).

and turns over that muscle to reach the front of the neck, where it will be afterwards described.

The **spinal accessory nerve** (*spinal portion*) appears at the posterior border of the sterno-cleido-mastoid near its centre, below the superficial cervical, and then crosses the posterior triangle of the neck downwards and backwards to the anterior border of the trapezius, beneath which it passes. It is accompanied by two small branches

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of the anterior primary divisions of the third and fourth cervical nerves, which lie below it, and it forms a plexiform communication with them beneath the trapezius, to which muscle it is distributed.

The **descending superficial branches of the cervical plexus** appear at the posterior border of the sterno-cleido-mastoid, below the spinal accessory, usually as a single trunk which arises by two roots from the anterior primary divisions of the third and fourth cervical nerves. This trunk, as it descends, divides into three nerves, namely, **suprasternal, supraclavicular,** and **supra-acromial,** which pass downwards over the clavicle, and will be afterwards referred to.

Muscles—Cervical Portion of the Trapezius—*Origin.*—(1) The inner third of the superior curved line of the occipital bone, and the external occipital protuberance ; and (2) the ligamentum nuchæ.

Insertion.—(1) The posterior border of the outer third of the clavicle ; and (2) the inner border of the acromion process of the scapula.

Nerve-supply.—(1) The spinal accessory nerve (spinal portion) ; and (2) branches from the cervical plexus, which are derived from the anterior primary divisions of the third and fourth cervical nerves. The nerves enter the deep surface of the muscle after passing beneath its anterior border a little above the clavicle, and they here form a plexiform communication with each other.

Blood-supply.—There is one specially named artery, called the **superficial cervical artery,** which is a branch of the transverse cervical, and, like the nerves, enters the deep surface of the muscle.

The fibres are directed downwards, forwards, and outwards.

Action.—The cervical fibres, acting from their origin, elevate the outer end of the clavicle and the point of the shoulder. Acting from their insertion they extend the head, and incline the neck towards the same side, the face being directed towards the opposite side.

The anterior border of the muscle forms the posterior boundary of the posterior triangle of the neck.

Occasionally a small muscle, called the **transversus nuchæ,** is met with, extending from the external occipital protuberance to the tendon of insertion of the sterno-cleido-mastoid. It may be fleshy or tendinous.

Ligamentum Nuchæ.—This is a strong fibrous band which occupies the median line of the neck. Its superficial fibres are attached superiorly to the external occipital protuberance, and inferiorly to the spine of the seventh cervical vertebra. Its deep fibres are attached to the external occipital crest, and to the spines of cervical vertebræ, from the second to the sixth inclusive. They also extend into the interspinous intervals, between the interspinales muscles, where they represent interspinous ligaments.

Insertion and Posterior Border of the Sterno-cleido-mastoid.—This muscle is inserted into (1) the outer surface of the mastoid process of the temporal bone, and (2) the superior curved line of

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the occipital bone over about its outer half, or more. The posterior border of the muscle forms the anterior boundary of the posterior triangle of the neck, and has the following nerves related to it: (1) the small occipital ascends along it to the head; (2) the great auricular passes upwards and forwards over it towards the lobule of the auricle; (3) the superficial cervical crosses it in a forward direction; (4) the spinal accessory appears from behind it, along with the branches of the third and fourth cervical nerves to the trapezius; and (5) the descending superficial branches of the cervical plexus emerge from underneath it.

The **glandulæ concatenatæ** belong to the deep cervical glands, and are situated along the posterior border of the sterno-cleido-mastoid muscle. They will be afterwards described.

The levator anguli scapulæ, rhomboids, serratus posticus superior, splenius, complexus, transversalis cervicis, trachelo-mastoid, semi-spinalis colli, intertransversales, and interspinales muscles will be found described in connection with the muscles of the back, see p. 268 *et seq.*

Second and Third Parts of the Occipital Artery.—At the mastoid process this vessel lies very deeply. Having crossed the rectus capitis lateralis muscle, it enters the occipital groove on the inner aspect of the mastoid process, where it is covered by the following structures, in order from the surface downwards: (1) sterno-cleido-mastoid; (2) splenius capitis; (3) trachelo-mastoid; (4) mastoid process; and (5) the posterior belly of the digastric. In its backward course the vessel rests, in succession, upon the insertions of the obliquus capitis superior and complexus, and it escapes from beneath the muscles covering it in the following order: posterior belly of the digastric, trachelo-mastoid, splenius capitis, and sterno-cleido-mastoid. After emerging from beneath the last-named muscle, it lies for a little in the posterior triangle, close to the apex, and then, piercing the occipital origin of the trapezius, it enters upon the third part of its course. This part ascends, along with the great occipital nerve, to the occipital region, where it divides into several long tortuous branches.

Branches.—The branches of the second and third parts are as follows: mastoid, posterior meningeal, arteria princeps cervicis, communicating, muscular, and terminal. The **mastoid artery** passes through the arterial fissure on the outer surface of the mastoid process, and supplies the diploë and mastoid cells, as well as the adjacent dura mater. The **posterior meningeal artery** enters the cranial cavity through the jugular foramen, and takes part in the supply of the dura mater of the posterior fossa. The **arteria princeps cervicis** arises under cover of the splenius capitis, and at the outer border of the complexus it divides into a superficial and deep branch. The *superficial branch* is distributed to the splenius capitis and trapezius, and anastomoses, in the latter muscle, with the superficial cervical artery. The *deep branch* passes beneath the complexus, and anastomoses, upon the semispinalis

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colli, with (1) the deep cervical of the superior intercostal of the second part of the subclavian, and (2) branches of the vertebral artery. The **communicating branches** enter the suboccipital triangle, where they anastomose with branches of the vertebral artery. The **muscular branches** supply the contiguous muscles. The **terminal branches** are at first two in number, but these soon divide into several long tortuous branches, which supply the occipitalis and the integument as high as the vertex. They anastomose with the posterior auricular, the posterior division of the superficial temporal, and their fellows of the opposite side.

The **occipital venous plexus** communicates with the posterior auricular, and the posterior branch of the superficial temporal, veins. It receives the *parietal emissary vein*, which emerges through the parietal foramen, and so a communication is established with the superior longitudinal sinus. Sometimes it receives a small *occipital emissary vein*, which emerges through an opening at the external occipital protuberance, and then a communication would be established with the torcular Herophili.

Two or three **occipital veins** emerge from the occipital plexus. The external vessel is known as the **posterior jugular vein.** It receives the *mastoid emissary vein*, which emerges through the mastoid foramen, and so an important communication is established with the lateral sinus. Having been reinforced by tributaries from the superficial structures at the upper part of the back of the neck, the posterior jugular vein passes on to the sterno-cleido-mastoid, where it opens into the external jugular. The **middle occipital vein** (inconstant) accompanies the occipital artery, and usually opens into the internal jugular. The **internal occipital vein,** having in some cases pierced the trapezius, passes beneath the complexus, and enters the suboccipital triangle. In this situation it joins the suboccipital plexus, from which the deep cervical and vertebral veins emerge.

Occipital Glands.—These glands are usually two in number, and lie over the occipital portion of the trapezius, or over the upper part of the complexus. They receive their afferent lymphatics from the back part of the scalp, and their efferent lymphatics pass to the superficial cervical glands.

Deep Cervical Artery.—This vessel is a branch of the superior intercostal of the second part of the subclavian. Having passed backwards between the transverse process of the seventh cervical vertebra and the neck of the first rib, it ascends upon the semi-spinalis colli, under cover of the complexus, towards the level of the spine of the axis, where it anastomoses with the deep branch of the arteria princeps cervicis of the occipital. In its course it furnishes a *spinal branch*, which enters the spinal canal through the intervertebral foramen for the eighth cervical nerve, and *muscular branches*, which anastomose with branches of the vertebral artery.

The **deep cervical vein** commences, within the suboccipital triangle, in the suboccipital plexus, which receives the internal occipital

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vein. It descends, in company with the deep cervical artery, to the lower part of the neck, where it passes forwards between the transverse process of the seventh cervical vertebra and the neck of the first rib, and ends by joining the vertebral vein just before that vessel terminates in the innominate vein.

In addition to the muscular branches of the occipital and deep cervical arteries, the deep muscles of the back of the neck receive twigs from the second part of the vertebral artery, which traverses the costo-transverse foramina of the upper six cervical vertebræ. These twigs pass backwards through the intertransverse spaces, and anastomose with branches of the arteria princeps cervicis and deep cervical arteries.

Suboccipital Region — Muscles — Rectus Capitis Posticus Major —*Origin.*—One of the tubercles in which the spine of the axis terminates.

Insertion.—The outer part of the inferior curved line of the occipital bone, and the subjacent area.

Nerve-supply.—The posterior primary division of the suboccipital nerve.

The direction of the fibres is upwards and outwards.

Action.—(1) To rotate the head towards the same side; and (2) to extend the head.

The muscle is triangular, and its insertion is slightly overlapped by the obliquus capitis superior.

Rectus Capitis Posticus Minor—*Origin.*—The posterior arch of the altas, close to, and encroaching upon, the posterior tubercle.

Insertion.—The inner third of the inferior curved line of the occipital bone, and the subjacent area as low as the foramen magnum.

Nerve-supply.—The posterior primary division of the suboccipital nerve.

The direction of the fibres is upwards in an expanded manner.

Action.—To extend the head.

The muscle is fan-shaped, and lies deeper than, and internal to, the rectus capitis posticus major.

Obliquus Capitis Inferior—*Origin.*—One of the tubercles in which the spine of the axis terminates.

Insertion.—The lower surface of the extremity of the transverse process of the atlas at its back part.

Nerve-supply.—The posterior primary division of the suboccipital nerve.

The direction of the fibres is outwards and slightly upwards.

Action.—To rotate the atlas, along with the head, towards the same side.

The muscle is thick and fleshy. At its origin it is interposed between the rectus capitis posticus major superiorly and the highest bundle of the semispinalis colli inferiorly. The great occipital nerve winds round its lower border.

Obliquus Capitis Superior—*Origin.*—The upper surface of the

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extremity of the transverse process of the atlas at its back part.

Insertion.—The occipital bone between the outer parts of the superior and inferior curved lines.

Nerve-supply.—The posterior primary division of the suboccipital nerve.

The direction of the fibres is upwards and inwards.

Action.—(1) To extend the head ; and (2) to act as a slight lateral flexor of the head.

The muscle is triangular.

Suboccipital Triangle.—This triangle is situated under cover of the upper part of the complexus, close below the occipital bone.

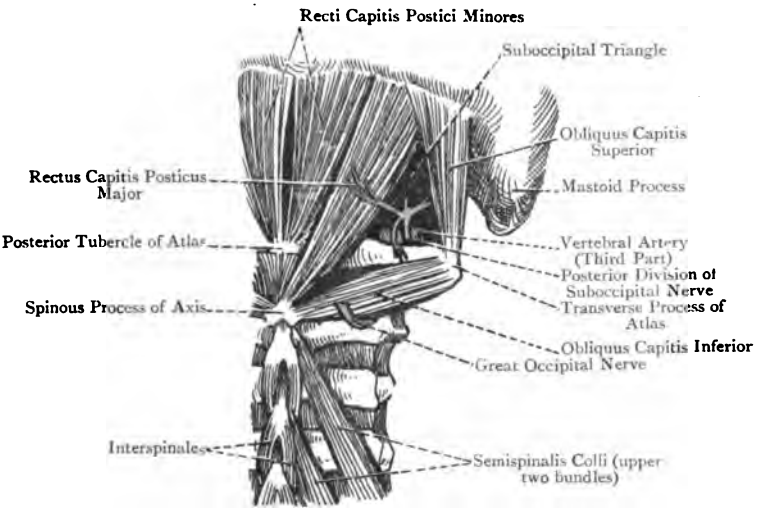

FIG. 419.—THE SUBOCCIPITAL TRIANGLE.

Boundaries—*Supero-internal.*—The rectus capitis posticus major. *Supero-external.*—The obliquus capitis superior. *Inferior.*—The obliquus capitis inferior. The **roof** is formed by the complexus, and the **floor** by half of the posterior arch of the atlas, and half of the posterior occipito-atlantal ligament. The **contents** are (1) the third part of the vertebral artery, (2) the suboccipital plexus of veins, and (3) the posterior primary division of the suboccipital nerve.

Third Part of the Vertebral Artery.—The vertebral artery, having emerged from the costo-transverse foramen of the atlas, enters upon the third part of its course, and takes a winding course backwards and inwards. It lies in the vertebrarterial groove of the atlas, the posterior primary division of the suboccipital nerve being beneath it, and it passes under an arched band of the

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posterior occipito-atlantal ligament. It leaves the suboccipital triangle by piercing the dura mater, and enters the cranial cavity through the foramen magnum. The third part of the vessel furnishes *muscular branches* to the adjacent muscles which anastomose with the arteria princeps cervicis of the occipital, and the deep cervical of the superior intercostal.

Suboccipital Plexus of Veins.—This plexus is formed by branches which proceed from (1) the intraspinal venous plexus, (2) the adjacent muscles, and (3) the occipital periosteum. It receives the internal occipital vein, and the blood is conveyed away from it by the deep cervical vein, already described, and the vertebral vein, which will be afterwards considered.

Posterior Primary Division of the Suboccipital Nerve.—This division passes backwards, as a single nerve, in the vertebrarterial groove of the atlas, lying between the bone and the third part of the vertebral artery. On entering the suboccipital triangle it divides into branches which supply the obliqui, recti postici, and complexus muscles.

Posterior Primary Divisions of the Cervical Spinal Nerves.—The cervical nerves are eight in number, the first being known as the **suboccipital nerve.** Each breaks up into an anterior and a posterior primary division. The posterior primary division of the first or suboccipital is single, and has just been described. The posterior primary divisions of the lower seven arise in the intervertebral foramina, and each soon divides into an external and internal branch. The *external branches* of all are distributed to the deep muscles, and do not become cutaneous. The *internal branch* of the posterior primary division of the second, which is of large size, constitutes the **great occipital nerve.** It winds round the lower border of the obliquus capitis inferior, and pierces the complexus, to which it gives branches. Thereafter it may pierce the trapezius to reach its cutaneous distribution, which has been already described. The *internal branches* of the third, fourth, and fifth are directed inwards *upon* the semispinalis colli, to which, as well as to the complexus, they give branches. Close to the cervical spinous processes they pass backwards, internal to the biventer cervicis (part of the complexus), and, having pierced the trapezius, they reach the integument, which they supply. The internal branch of the posterior primary division of the third, before piercing the trapezius, gives off a small ascending branch, known as the **least** or **third occipital.** It passes upwards, lying at first under cover of the trapezius, and then passing through it, to reach the occipital integument. The *internal branches* of the posterior primary divisions of the sixth, seventh, and eighth are directed inwards towards the cervical spinous processes *beneath* the semispinalis colli, and are distributed to the adjacent muscles. They do not furnish any branches to the integument.

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The Scalp and Temporal Region.

Scalp—Fascia.—The superficial fascia is firm and granular, and is separated into lobules by fibrous processes which pass between the skin and the epicranial aponeurosis. The deep fascia is represented by the epicranial aponeurosis of the occipito-frontalis muscle, to be presently described.

Nerves of the Scalp Proper.—The great, small, and least or third occipital nerves, and the mastoid branch of the great auricular have been already described. In the **fronto-parietal region** two sensory nerves are met with, namely, the supra-orbital and supra-trochlear, both of which are derived from the frontal nerve, which is one of the branches of the ophthalmic division of the fifth cranial nerve.

The **supra-orbital nerve,** which is of large size, leaves the orbit through the supra-orbital foramen. It then ascends, lying at first beneath the upper part of the orbicularis palpebrarum and the frontalis muscles, but subsequently piercing the latter muscle in two branches, outer and inner. The outer branch is the larger of the two, and its offsets extend well back over the parietal region. As the supra-orbital nerve passes through the supra-orbital foramen it furnishes one or two twigs to the mucous membrane of the frontal air-sinus and to the diploë of the frontal bone, and, after emerging from the foramen, it sends downwards palpebral branches to the integument of the upper eyelid. Thereafter the nerve supplies the integument of the fronto-parietal region.

The outer and inner branches of the supra-orbital nerve sometimes emerge from the orbit separately, the outer branch passing through the supra-orbital foramen, and the inner branch passing over the frontal notch

The **supratrochlear nerve,** which is of small size, is internal to the supra-orbital nerve. It leaves the orbit close to the internal angular process of the frontal bone, where it lies above the trochlea or pulley of the superior oblique muscle of the eyeball. It then ascends beneath the upper part of the orbicularis palpebrarum and the frontalis muscles, and, piercing the latter muscle, it has a limited distribution to the frontal integument close to the median line. As the nerve leaves the orbit it furnishes palpebral twigs to the inner part of the integument of the upper eyelid.

Arteries.—The third part of the occipital artery has been already described. The arteries of the **fronto-parietal region** are three in number, namely, the supra-orbital, frontal, and anterior branch of the superficial temporal.

The **supra-orbital artery** is a branch of the ophthalmic, and emerges from the orbit with the supra-orbital nerve. It is distributed to the structures covering the frontal bone, and anastomoses with the frontal, and the anterior division of the superficial temporal, arteries. In the supra-orbital foramen it furnishes one or two branches to the mucous membrane of the frontal air-sinus and to

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the diploë of the bone, and, after emerging from the foramen, it sends downwards palpebral branches to the integument of the upper eyelid.

The **supra-orbital vein** passes downwards and inwards to a point just above the inner canthus, where it joins the frontal vein. In this manner the angular vein is formed, which is the commencement of the facial vein. The supra-orbital vein receives tributaries from the frontal region and the upper eyelid, and in the region of the inner canthus it communicates with the superior ophthalmic vein. It also communicates with the superior ophthalmic vein through the supra-orbital notch, and this communication receives the frontal diploic vein, which returns the blood from the diploë of the frontal bone and mucous membrane of the frontal air-sinus.

The **frontal artery,** like the supra-orbital, is a branch of the ophthalmic, and emerges from the orbit with the supratrochlear nerve. It is distributed to the structures over the frontal bone internal to the supra-orbital artery, with which it anastomoses, as well as with its fellow of the opposite side.

The **frontal vein,** of large size, passes downwards near the median line, and at a point just above the inner canthus is joined by the supra-orbital vein, the resultant vessel being the angular vein. At the root of the nose it communicates with its fellow of the opposite side by a transverse vessel, called the **transverse nasal vein.**

The supra-orbital and frontal veins communicate with each other, and with the tributaries of the anterior branch of the superficial temporal vein.

The anterior branch of the superficial temporal artery will be described in connection with the temporal region.

Occipito-frontalis.—This muscle consists of the following parts: (1) the occipitalis, (2) the frontalis, and (3) the epicranial aponeurosis.

Occipitalis.—This consists of two thin fleshy bellies, right and left. *Origin.*—(1) The outer parts of the highest and superior curved lines of the occipital bone; and (2) the outer surface of the mastoid process of the temporal bone, immediately above the insertion of the sterno-cleido-mastoid muscle.

Insertion.—The epicranial aponeurosis.

Each belly forms a thin, broad sheet, the length of the fasciculi being about 1½ inches. The two bellies, right and left, are separated towards the median line by a portion of the epicranial aponeurosis, which here dips down between them.

Frontalis.—This consists of two parts, right and left, which are separated superiorly by a narrow angular portion of the epicranial aponeurosis, but inferiorly, and for the most part, they are in contact. *Origin.*—(1) The subcutaneous tissue of the eyebrow and root of the nose, where the fibres blend with the upper part of the orbicularis palpebrarum and the corrugator supercilii; and (2) slightly from the external angular process of the frontal bone, and from the nasal bone.

Insertion.—The epicranial aponeurosis, a little below the level of the fronto-parietal suture.

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The fasciculi are about 3½ inches long, and the innermost fibres inferiorly are regarded by some as being prolonged downwards upon the nasal bone as the pyramidalis nasi muscle.

Epicranial Aponeurosis.—This is the intermediate tendon of the occipito-frontalis muscle. It forms an aponeurotic stratum beneath the superficial fascia, and is connected to the skin by fibrous processes, which separate the superficial fascia into lobules. Its deep surface is loosely connected by areolar tissue to the subjacent

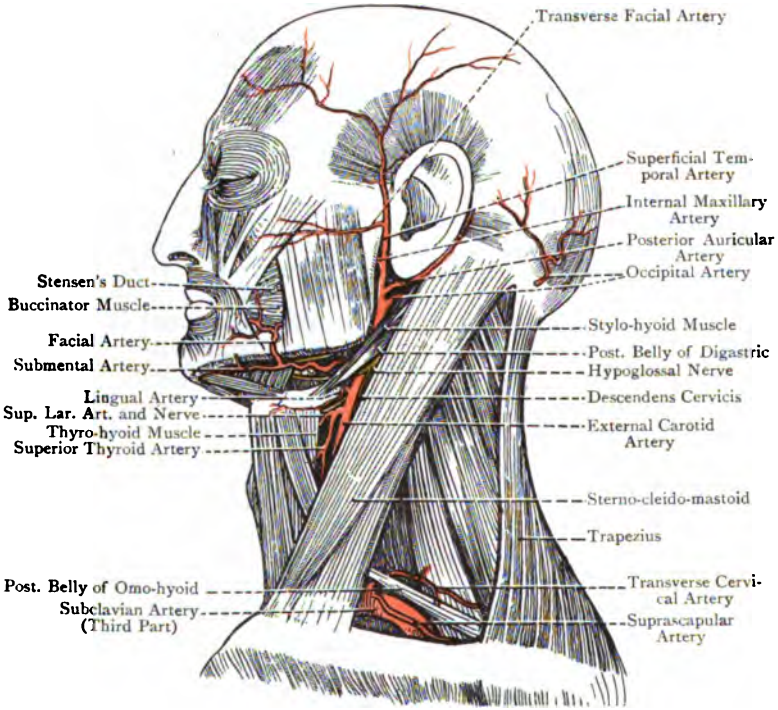

FIG. 420.—THE LEFT SIDE OF THE HEAD AND NECK.

(The Platysma Myoides has been removed).

periosteum. Posteriorly it gives insertion to the two bellies of the occipitalis muscle, and, in the interval between these, it dips down to be attached to the inner part of the highest curved line of the occipital bone and the external occipital protuberance. Anteriorly it gives insertion to the two halves of the frontalis muscle. Laterally, below the superior temporal ridge, it is prolonged downwards over the temporal fascia as a delicate expansion, which gives origin to the attollens auriculam and attrahens auriculam muscles.

Nerve-supply.—The occipitalis muscle is supplied by the pos-

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terior auricular branch of the facial nerve, and the frontalis muscle is supplied by the temporal branches of the temporo-facial division of the facial nerve.

Action.—The two bellies of the occipitalis draw backwards the epicranial aponeurosis, and along with it the scalp. The two halves of the frontalis, acting from below, draw forwards the epi cranial aponeurosis, and along with it the scalp. Acting from above they elevate the eyebrows, and throw the skin of the frontal region into transverse wrinkles. When the occipitalis and frontalis act simultaneously the scalp is drawn backwards, and the eyebrows are forcibly raised. When the two muscles act alternately the scalp is drawn backwards and forwards.

Pericranium.—This is the periosteum of the cranium, and it is loosely connected by areolar tissue to the superjacent epicranial aponeurosis.

Temporal Region—Nerves.—These are as follows: (1) the temporal branches of the temporo-facial division of the facial nerve; (2) the auriculo-temporal nerve; and (3) the temporal branch of the orbital or temporo-malar nerve.

The **temporal branches of the temporo-facial division of the facial nerve** pass upwards a little in front of the auricle, and supply the following muscles: the frontalis, upper part of the orbicularis palpebrarum, corrugator supercilii, attollens auriculam, and attrahens auriculam. They communicate with the auriculo-temporal, temporal branch of the orbital, and supra-orbital nerves.

The **auriculo-temporal nerve** is a branch of the posterior division of the inferior maxillary nerve, which is the third division of the fifth cranial nerve. It emerges from the upper part of the parotid gland, and ascends immediately in front of the auricle, in company with the superficial temporal artery, lying between that vessel and the auricle.

Branches.—In this part of its course the nerve furnishes the following branches: (1) two *meatal branches* to the meatus auditorius externus, which enter the canal between its osseous and cartilaginous walls, and supply the integument of the meatus, the upper of the two branches giving an offset to the membrana tympani; (2) two *anterior auricular branches*, which supply the skin of the tragus and outer aspect of the auricle over its upper half; and (3) *temporal branches*, which supply the integument above and in front of the auricle, and of the temporal region generally.

The **temporal branch of the orbital or temporo-malar nerve** from the superior maxillary is of small size, and pierces the temporal fascia about 1 inch above the anterior part of the zygoma, and close behind the marginal process of the malar bone. Having communicated with one of the temporal branches of the facial nerve, it has a limited distribution to the integument of the anterior part of the temporal region.

The **superficial temporal artery** is one of the terminal branches of the external carotid artery, from which it arises within the parotid

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gland on a level with the neck of the lower jaw. Emerging from the gland it ascends in front of the auricle, in company with the auriculo-temporal nerve, which lies between the vessel and the auricle, and, after a course of about 2 inches, it divides into its two terminal branches.

Branches. — These are as follows: (1) transverse facial; (2) articular; (3) anterior auricular; (4) middle temporal; (5) orbital; and (6) terminal, namely, anterior temporal and posterior temporal.

The **transverse facial branch** will be described in connection with the face. It arises within the parotid gland, and in its course

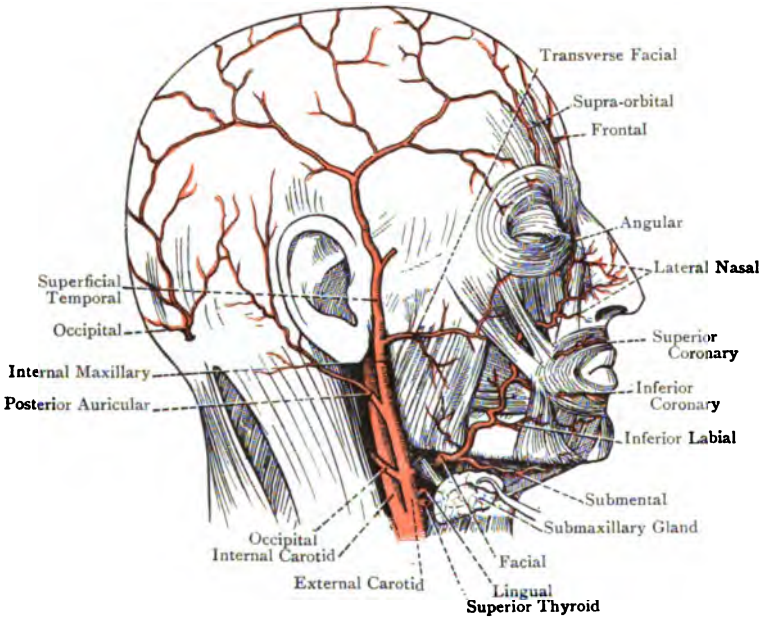

FIG. 421.—THE ARTERIES OF THE RIGHT SIDE OF THE HEAD (AFTER L. TESTUT'S 'ANATOMIE HUMAINE').

furnishes glandular branches. The **articular branches** supply the temporo-mandibular joint. The **anterior auricular branches** supply the outer aspect of the auricle, and in part the meatus auditorius externus. The **middle temporal branch** pierces the temporal fascia and temporal muscle immediately above the zygoma, and then ascends in a groove on the outer surface of the squamous part of the temporal bone. It gives branches to the temporal muscle, and anastomoses with the deep temporal arteries, which are branches of the internal maxillary. The **orbital branch** passes forwards close above the zygoma, where it lies between the two layers of the temporal fascia. It is distributed to the outer part of the orbi-

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cularis palpebrarum muscle. The **anterior temporal branch** passes forwards and upwards in a tortuous manner, and is distributed to the structures covering the frontal bone, where it anastomoses with the supra-orbital and frontal branches of the ophthalmic artery, and with its fellow of the opposite side. The **posterior temporal branch** takes an arched course upwards and backwards above the auricle, supplying the adjacent structures, and anastomosing with the posterior auricular and occipital arteries, and with its fellow of the opposite side.

The **superficial temporal vein** is formed in front of the auricle by the union of an anterior and a posterior branch, the former communicating freely with the supra-orbital and frontal veins, and the latter with the posterior auricular vein and the occipital venous plexus. Above the zygoma it is joined by the middle temporal vein, which originates in a plexus in the temporal fossa, and pierces the temporal muscle and temporal fascia, receiving in its course the orbital vein. The superficial temporal vein then descends over the zygoma and enters the parotid gland, within which it receives the anterior auricular, articular, and transverse facial veins. Finally, it joins the internal maxillary vein about the level of the neck of the lower jaw to form the temporo-maxillary vein.

Extrinsic Muscles of the Auricle.—These are three in number, as follows: (1) attollens auriculam; (2) attrahens auriculam; and (3) retrahens auriculam.

Attollens Auriculam—*Origin.*—The lateral part of the epicranial aponeurosis.

Insertion.—The inner or cranial surface of the auricle over the convexity corresponding to the fossa of the antihelix on its outer surface.

Nerve-supply.—The temporal portion of the temporo-facial division of the facial nerve. The posterior part of the muscle may be supplied by the posterior auricular branch of the facial nerve.

The muscle is very thin, pale, and fan-shaped, and its fibres converge in a downward direction.

Action.—To raise the auricle.

Attrahens Auriculam—*Origin.*—The lateral part of the epicranial aponeurosis in front of the attollens auriculam, with which muscle it is continuous.

Insertion.—The anterior part of the helix of the auricle.

Nerve-supply.—The temporal portion of the temporo-facial division of the facial nerve.

The muscle is directed backwards.

Action.—To draw forwards the auricle.

Retrahens Auriculam—*Origin.*—The upper part of the outer surface of the mastoid process of the temporal bone.

Insertion.—The inner or cranial surface of the auricle over the convexity of the concha.

Nerve-supply.—The posterior auricular branch of the facial nerve.

The muscle is directed forwards.

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Action.—To draw back the auricle.

The retrahens auriculam is more distinct than the other two muscles, and is usually arranged in two bundles.

Posterior Auricular Nerve.—This is a branch of the facial nerve immediately after it emerges from the aqueduct of Fallopius through the stylo-mastoid foramen. It passes upwards between the mastoid process and the auricle, where it lies deeply in company with the posterior auricular artery, and it divides into two branches—auricular and occipital. The *auricular branch* supplies the retrahens auriculam muscle on its deep aspect, and those intrinsic muscles of the auricle which lie on its inner or cranial aspect. It may also send a branch upwards beneath the retrahens auriculam to supply the posterior part of the attollens auriculam. The *occipital branch* passes backwards, and supplies the corresponding half of the occipitalis muscle. The posterior auricular nerve communicates with the small occipital and great auricular nerves, and also with the auricular branch (Arnold's nerve) of the pneumogastric.

Nerve of Arnold.—This is the auricular branch of the ganglion of the root of the pneumogastric nerve. Having traversed the auricular canaliculus in the petrous part of the temporal bone, it emerges through the auricular or tympano-mastoid fissure, between the mastoid process and tympanic plate, and thereafter divides into two branches—auricular and communicating. The *auricular branch* takes part in the supply of the inner or cranial surface of the auricle, and also supplies the lower and back part of the meatus auditorius externus ; and the *communicating branch* joins the posterior auricular nerve.

Posterior Auricular Artery.—This vessel is one of the two posterior branches of the external carotid artery, the other branch being the occipital artery. Having passed backwards and upwards under cover of the parotid gland, it lies deeply between the mastoid process and the auricle, in close relation to the posterior auricular nerve, and divides into two branches—auricular and mastoid. The *auricular branch* supplies the inner or cranial surface of the auricle and adjacent structures, and it anastomoses with the posterior branch of the superficial temporal artery. The *mastoid branch* passes backwards to the corresponding half of the occipitalis muscle, and anastomoses with the occipital artery.

The **posterior auricular vein** is of fairly large size, and returns the blood from the lateral portion of the scalp posteriorly, and the inner surface of the auricle. Its radicles communicate with the occipital plexus and with the posterior branch of the superficial temporal vein. The vessel passes downwards and forwards over the upper part of the sterno-cleido-mastoid muscle, and terminates about the level of the angle of the lower jaw by joining the posterior division of the temporo-maxillary vein to form the external jugular vein.

Posterior Auricular, or Mastoid, Glands.—These glands lie close

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to the insertion of the sterno-cleido-mastoid muscle. They receive their afferent lymphatics from the lateral part of the back of the scalp and the back of the auricle, and their efferent lymphatics pass to the superficial cervical glands.

Temporal Fascia.—This is a strong aponeurosis which covers the temporal muscle. Superiorly it is attached from before backwards to the temporal border of the malar bone, the superior temporal ridge of the frontal and parietal bones, and the supramastoid crest of the temporal bone. Inferiorly it divides into two laminæ, which are attached to the outer and inner margins of the upper border of the zygomatic arch. Between these two laminæ there are a small amount of adipose tissue and the orbital branch of the superficial temporal artery. Superficial to the fascia there are the delicate prolongation of the lateral portion of the epicranial aponeurosis and the attollens and attrahens auriculam muscles. Superiorly the fascia gives origin, by its deep surface, to superficial fibres of the temporal muscle, but it is separated from that muscle towards the zygoma by adipose tissue.

Temporal Muscle — *Origin.*—(1) The temporal fossa, extending as high as the inferior temporal ridge of the frontal and parietal bones, and as low as the infratemporal crest on the external surface of the great wing of the sphenoid; and (2) the deep surface of the temporal fascia over its upper part.

The muscle is fan-shaped. The anterior fasciculi descend almost vertically; the posterior fasciculi pass almost horizontally forwards; and the intervening fasciculi descend with varying degrees of obliquity.

A complete description of the temporal muscle will be found on p. 1122.

The Cranial Cavity.

The meninges of the encephalon, namely (1) the dura mater, with its septa and venous sinuses, (2) the arachnoid membrane, and (3) the pia mater, will be found described on p. 1355, *et seq.*

Cranial Nerves at the Base of the Skull.—The cranial nerves are arranged in twelve pairs, and as they leave the cranial cavity they receive sheaths from the meninges of the encephalon.

The **olfactory bulb** rests upon one-half of the cribriform plate of the ethmoid bone. Through the foramina of that plate it receives about twenty **olfactory filaments,** which arise as the axons of the olfactory cells of the olfactory mucous membrane of the nasal fossa.

The **nasal nerve** passes forwards and inwards beneath the dura mater on one-half of the cribriform plate of the ethmoid bone to the *nasal slit.*

The **optic nerve** passes forwards and outwards from the optic commissure to the optic foramen, through which it enters the orbit. It is accompanied by the ophthalmic artery, which lies beneath it.

The **third** or **oculo-motor nerve** pierces the dura mater, which

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forms the outer wall of the cavernous sinus, a little in front of the posterior clinoid process of the sphenoid bone.

The **fourth** or **trochlear nerve,** of small size, pierces the dura mater at a point a little behind the posterior clinoid process of the sphenoid bone, external to the third nerve, and beneath the free margin of

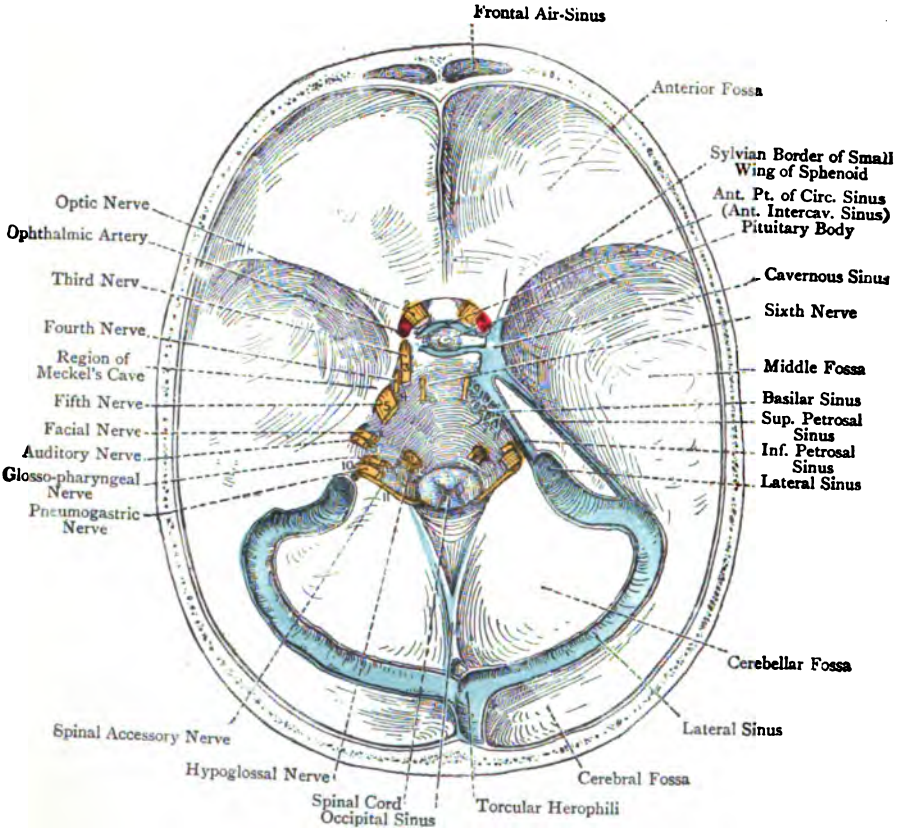

FIG. 422.—THE INTERNAL BASE OF THE SKULL, SHOWING THE CRANIAL NERVES AND VENOUS SINUSES.

the tentorium cerebelli. Thereafter it traverses the outer wall of the cavernous sinus.

The **fifth** or **trigeminal nerve** consists of two roots—sensory and motor. These two roots pierce the dura mater at the apex of the petrous part of the temporal bone, and enter a recess of the dura mater, called *Meckel's cave*, where they will be presently described.

The **sixth** or **abducent nerve** pierces the dura mater at the outer border of the dorsum sellæ of the sphenoid bone, a little below the

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posterior clinoid process, where it occupies a notch on the bone. It lies a little to the inner side of the fifth nerve.

The **seventh** or **facial nerve,** the **eighth** or **auditory nerve,** and the **pars intermedia of Wrisberg,** accompanied by the internal auditory artery, enter the meatus auditorius internus.

The **ninth** or **glosso-pharyngeal nerve,** the **tenth** or **pneumogastric nerve,** and the **eleventh** or **spinal accessory nerve** pass through the middle compartment of the jugular foramen. This foramen is divided into three compartments, namely, antero-internal, middle, and postero-external. The *antero-internal compartment* gives passage to the inferior petrosal sinus. The *middle compartment* transmits the glosso-pharyngeal, pneumogastric, and spinal accessory nerves, in this order from before backwards. The glosso-pharyngeal nerve pierces the dura mater separately, and receives special sheaths from the dura mater and arachnoid membrane. The pneumogastric and spinal accessory nerves pass through the same aperture in the dura mater, and receive common sheaths from the dura and arachnoid membrane. The *postero-external compartment* transmits the lateral sinus, which terminates in the internal jugular vein.

The **twelfth** or **hypoglossal nerve** pierces the dura mater in two bundles, which pass through separate apertures. As these bundles pass through the anterior condylar foramen they unite to form one nerve.

Structures passing through the Foramen Magnum.—(1) The medulla oblongata, with its membranes, passes out and becomes the spinal cord. (2) The *spinal portion* of the spinal accessory nerve, of either side, having ascended from the interval between the posterior roots of the cervical spinal nerves and the ligamentum denticulatum, enters the cranial cavity. It then turns outwards to the middle compartment of the jugular foramen, where it meets the *bulbar portion* of the nerve, with which it becomes closely connected as it passes through the foramen. (3) The vertebral artery of each side enters the cranial cavity, after having left the vertebrarterial groove on the upper aspect of the posterior arch of the atlas. (4) The two anterior spinal branches of the vertebral arteries descend on the front of the medulla oblongata, and, inclining inwards towards each other, they unite in passing through the foramen magnum to form the anterior spinal artery. (5) The two posterior spinal branches of the vertebral arteries pass outwards through the foramen magnum.

Gasserian Ganglion.—The Gasserian ganglion occupies the Gasserian depression on the superior surface of the petrous part of the temporal bone near the apex, where it lies in a recess of the dura mater, called *Meckel's cave.* It is somewhat semilunar, being convex in front and concave behind, and measures fully ½ inch from before backwards. It is associated with the sensory root of the fifth nerve, which, before entering the posterior concave aspect of the ganglion, becomes expanded, its fasciculi at the same

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time becoming separated and assuming a plexiform arrangement. Internally the ganglion is intimately related to the back part of the cavernous sinus and the internal carotid artery at the foramen lacerum medium, and on this aspect it receives delicate filaments from the carotid sympathetic plexus. The motor root of the fifth nerve, small in size, lies in close contact with the deep surface of the ganglion; but there is no blending of the two sets of fibres, the motor root passing independently in an outward direction to the foramen ovale. The great superficial petrosal nerve, on its way to the foramen lacerum medium, passes beneath the ganglion.

The ganglion contains cells similar to those of a spinal ganglion, and it receives its blood from the middle and small meningeal arteries.

Branches.—The branches of the ganglion arise from its anterior convex aspect, and are known as *divisions*. They are as follows: the first or ophthalmic division; the second or superior maxillary division; and the third or inferior maxillary division. The ophthalmic and superior maxillary nerves are entirely sensory, but the inferior maxillary nerve, being joined by the motor root, is both sensory and motor.

The **first division of the fifth nerve,** or the **ophthalmic nerve,** is the smallest of the three branches of the ganglion. It passes forwards in the outer wall of the cavernous sinus, where it lies below the fourth nerve. On approaching the sphenoidal fissure it parts with its chief branches, in the following order from behind forwards: (1) **nasal**, (2) **lachrymal**, and (3) **frontal,** the last-named representing the continuation of the nerve. All these three branches enter the orbit through the sphenoidal fissure. As the ophthalmic nerve passes forwards it receives a communicating branch from the cavernous sympathetic plexus, and it furnishes a *recurrent meningeal branch* to the tentorium cerebelli. It also communicates with each of the third, fourth, and sixth nerves.

The **second division of the fifth,** or the **superior maxillary nerve,** passes horizontally forwards for a short distance in the lower part of the outer wall of the cavernous sinus, and it leaves the cranial cavity through the foramen rotundum, which leads to the sphenomaxillary fossa. Before leaving the cranial cavity it furnishes a delicate *recurrent meningeal branch* to the dura mater of the middle fossa.

The **third division of the fifth,** or the **inferior maxillary nerve,** is the largest of the three branches of the ganglion. It passes downwards to the foramen ovale, through which it leaves the cranial cavity, and so enters the zygomatic fossa. It is accompanied by the motor root of the fifth nerve, which joins it as it passes through the foramen ovale. The *recurrent meningeal branch* of the inferior maxillary nerve is not given off until after the parent trunk has issued through the foramen ovale, and it enters the cranial cavity through the foramen spinosum, in company with the middle meningeal artery. It then divides into two offsets, one of which supplies the dura mater over the great wing of the sphenoid bone,

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and the other passes through the fissure between petrous and squamous parts of the temporal bone to supply the mucous membrane of the mastoid cells.

Great Superficial Petrosal Nerve.—This nerve is a branch of the geniculate ganglion of the facial nerve in the aqueduct of Fallopius. It enters the middle fossa of the base of the skull through the hiatus Fallopii, and passes forwards and inwards in a groove on the superior surface of the petrous part of the temporal bone. Having passed beneath the Gasserian ganglion, it enters the upper part of the foramen lacerum medium, where it is placed on the outer side of the internal carotid artery, and it joins the great deep petrosal nerve from the carotid sympathetic plexus. In this manner the Vidian nerve is formed, which enters the pterygoid or Vidian canal by its opening on the anterior aspect of the foramen lacerum medium, and so reaches Meckel's ganglion in the spheno-maxillary fossa. The great superficial petrosal nerve is accompanied by the petrosal branch of the middle meningeal artery.

Small Superficial Petrosal Nerve.—This nerve represents the continuation, through the tympanic plexus, of the tympanic branch (Jacobson's nerve) of the glosso-pharyngeal nerve. It is reinforced by a small branch from the geniculate ganglion of the facial nerve, which joins it as it traverses a small canal in the petrous part of the temporal bone, beneath the canal for the tensor tympani muscle. The nerve enters the middle fossa through the accessory hiatus on the superior surface of the *pars petrosa*. It then passes for a little forwards and inwards, and leaves the cranial cavity through the canaliculus innominatus (when present), or through the fissure between the pars petrosa and the great wing of the sphenoid, or, it may be, through the foramen ovale, after which it terminates in the otic ganglion.

External Superficial Petrosal Nerve.—This nerve, which is inconstant, passes from the sympathetic plexus on the middle meningeal artery backwards and outwards on the superior surface of the petrous part of the temporal bone, and it leaves the cranial cavity through a minute aperture situated within the thin margin of the hiatus Fallopii. It terminates in the geniculate ganglion of the facial nerve.

Interior of the Cavernous Sinus.—The interior of this sinus is broken up by a number of delicate trabeculæ, which are arranged in a reticular manner. The outer wall of the sinus contains the following cranial nerves, in order from above downwards : the third, the fourth, the ophthalmic division of the fifth, and the superior maxillary division of the fifth. These nerves, as they pass forwards, are separated from the blood-current by the endothelial lining of the outer wall of the sinus. The cavity of the sinus is traversed by (1) the cavernous part of the internal carotid artery, accompanied by the cavernous sympathetic plexus, and (2) the sixth cranial nerve, which lies in close contact with the outer side of the internal carotid artery. These structures are also separated from the blood-current by the endothelial lining of the sinus.

For the processes and other sinuses of the dura mater see p. 1358, *et seq.*

Cavernous Part of the Internal Carotid Artery.—This part of the internal carotid artery lies within the cavernous sinus, which occupies the cavernous groove on the lateral aspect of the body of the sphenoid bone. It is separated from the blood-current by the endothelial lining of the sinus. The course of the vessel is at first upwards, between the lingula sphenoidalis and the posterior petrosal

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process of the sphenoid ; then forwards, as far as the anterior clinoid process of the sphenoid ; and, finally, upwards internal to the anterior clinoid process. In the latter situation it pierces the dura mater which forms the roof of the cavernous sinus, and enters upon the cerebral part of its course.

The vessel is accompanied by the cavernous sympathetic plexus, and the sixth cranial nerve lies in close contact with its outer side, all being invested by the endothelial lining of the sinus.

Branches.—These are as follows : *pituitary*, to the pituitary body ; *ganglionic* to the Gasserian ganglion ; *cavernous*, to the wall of the cavernous sinus, and to the third, fourth, fifth, and sixth cranial nerves ; *meningeal*, to the dura mater of the middle cranial fossa ; and the *ophthalmic artery*. The latter vessel arises from the cavernous part of the internal carotid on the inner side of the anterior clinoid process, and it enters the orbit, with the optic

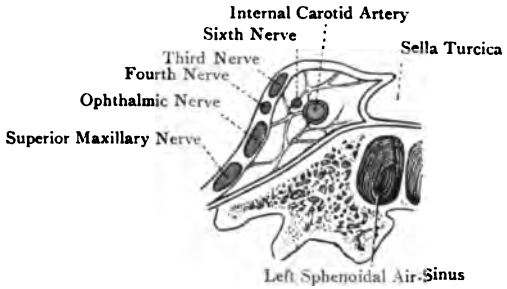

FIG. 423.—DIAGRAM OF THE LEFT CAVERNOUS VENOUS SINUS AND ITS OUTER WALL, SHOWING THE RELATIVE POSITIONS OF THE CONTAINED STRUCTURES (POSTERIOR VIEW).

nerve, through the optic foramen, lying at first beneath the nerve, and then on its outer side.

Cavernous Sympathetic Plexus.—This plexus is situated principally on the inner and lower aspects of the bend which the cavernous part of the internal carotid artery describes internal to the anterior clinoid process. Its branches are as follows : (1) *vascular*, to the internal carotid artery and its branches ; (2) *pituitary*, to the pituitary body ; (3) *communicating*, to the third, fourth, ophthalmic division of the fifth, and sixth cranial nerves ; and (4) the *sympathetic root* of the ciliary ganglion. The last-named branch enters the orbit through the sphenoidal fissure.

The **pituitary body** (*hypophysis cerebri*) is a small oval mass which is situated in the pituitary fossa, or sella turcica, of the sphenoid bone. It lies under cover of a circular fold of the dura mater, called the *diaphragma sellæ*, in the centre of which is an opening for the passage of the infundibulum. Its long measurement extends transversely, and it consists of two lobes—anterior or buccal, and posterior or cerebral. The anterior lobe is the larger of the two, and the posterior

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lobe is connected with the anterior part of the tuber cinereum by means of the infundibulum.

The **infundibulum** projects downwards from the anterior part of the tuber cinereum to the posterior lobe of the pituitary body. Its upper part is hollow, and contains a funnel-shaped diverticulum of the cavity of the third ventricle.

Structure.—The **anterior lobe** consists of several tubules, lined with epithelium, and invested by capillary bloodvessels. The **posterior lobe,** though developed from the brain, is destitute of nervous elements. It is composed of a reticulum of connective tissue, which contains branched cells.

Development.—The **anterior lobe** is developed from a diverticulum of the buccal or stomatodæal epiblast, which is known as the **pouch of Rathke.** The diverticulum grows upwards, and, when the cranio-pharyngeal canal of early life becomes closed, the connection of the diverticulum with the buccal epiblast is severed. The diverticulum thereafter becomes converted into tubules, which form the anterior lobe. The **posterior lobe** of the pituitary body and the infundibulum, which is connected with it, are developed as a diverticulum which grows downwards from that part of the thalamencephalon or diencephalon which forms the floor of the third ventricle. The cavity of the diverticulum remains permanent in the upper part of its infundibular portion, but elsewhere it becomes obliterated. The lower part of the diverticulum thereafter becomes converted into a reticulum of connective tissue, with branched cells, which forms the posterior lobe.

Side of the Neck.

The side of the neck has a quadrilateral outline, the boundaries of which are as follows : *superior*, one half of the base of the inferior maxilla, and a line prolonged from the angle of that bone over the mastoid process to the inner third of the superior curved line of the occipital bone; *inferior*, the clavicle, and one half of the upper border of the manubrium sterni; *anterior*, the middle line of the neck, that is to say, a line connecting the symphysis of the inferior maxilla with the centre of the upper border of the manubrium sterni; and *posterior*, a line connecting the inner third of the superior curved line of the occipital bone with the outer third of the clavicle.

Landmarks.—The base and angle of the inferior maxilla can easily be felt, and the clavicle, together with the upper border of the manubrium sterni, is conspicuous. A deep depression, called the suprasternal or jugular fossa, is perceptible above the upper border of the manubrium sterni, lying between the sternal heads of origin of the sterno-cleido-mastoid muscles. The outline of the sterno-cleido-mastoid muscle is readily discernible when the head is turned so as to direct the face towards the opposite shoulder. The muscle extends in a diagonal direction from the sterno-clavicular joint to the mastoid process and outer half or two-thirds of the superior curved line of the occipital bone, and it divides the side of the neck into two triangles — anterior and posterior. A small triangular interval may be felt between the sternal and clavicular heads of origin of the sterno-cleido-mastoid, just above the inner end of the clavicle, in which the common carotid artery and internal jugular vein lie deeply. The external

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jugular vein crosses the sterno-cleido-mastoid muscle in the direction of a line extending from a point just behind the angle of the inferior maxilla to a point above the centre of the clavicle, and it is accompanied by the superficial cervical glands. The common carotid artery lies under cover of the anterior border of the sterno-cleido-mastoid muscle, in the direction of a line drawn from the sterno-clavicular joint to a point midway between the angle of the inferior maxilla and the tip of the mastoid process of the temporal bone. The vessel extends along this line as high as the level of the upper border of the thyroid cartilage, and thereafter it is replaced by the external carotid artery. The internal jugular vein is close to the outer side of the common carotid artery, and the pneumogastric nerve lies deeply between the two vessels. If deep pressure is made over the common carotid artery, on a level with the cricoid cartilage of the larynx, the tubercle of the costal process of the sixth cervical vertebra (commonly spoken of as the anterior tubercle of the transverse process) may be felt. It is known as the *carotid tubercle of Chassaignac.*

The commencement of the right innominate vein and the bifurcation of the innominate artery lie behind the upper border of the right sterno-clavicular joint; and the commencement of the left innominate vein and the left common carotid artery lie behind the left sterno-clavicular joint. Near the middle line of the neck the anterior jugular vein descends vertically. The spinal portion of the spinal accessory nerve passes downwards and outwards beneath the anterior border of the sterno-cleido-mastoid to pierce the deep part of that muscle at about the junction of the upper fourth and lower three-fourths. The nerve is met with fully 1 inch below the tip of the mastoid process, and in the direction of a line let fall vertically from the mastoid tip. It is very nearly on a level with the body of the hyoid bone. Along the posterior border of the sterno-cleido-mastoid the lymphatic glands, known as the glandulæ concatenatæ, may be felt.

Important structures occupy the middle line of the neck, and can be usually distinguished without difficulty. These are as follows, in order from above downwards: (1) the body of the hyoid bone, lying just below the inferior maxilla, and having the great cornu projecting backwards and upwards on either side; (2) the thyro-hyoid membrane; (3) the thyroid cartilage, with its prominent angle or isthmus (pomum Adami) in the middle line, leading up to the V-shaped thyroid notch on the upper border, and its expanded ala on either side, each of which terminates posteriorly in a superior and an inferior cornu; (4) the crico-thyroid membrane; (5) the narrow, anterior part of the cricoid cartilage, which coincides with the level at which the anterior belly of the omo-hyoid muscle crosses the carotid sheath; and (6) the rings of the trachea, which, however, are covered superiorly by the isthmus of the thyroid body, and inferiorly by the sterno-hyoid and sterno-thyroid muscles and adipose tissue.

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The lateral lobes of the thyroid body may be felt on either side of the larynx and trachea as low as about the fifth ring ; and, in young children, the thymus body extends upwards upon the trachea for some distance above the manubrium sterni.

The great cornu of the hyoid bone is the guide to the lingual artery for operative purposes, the vessel lying just above the great cornu.

The upper border of the thyroid cartilage is on a level with the disc between the bodies of the third and fourth cervical vertebræ.

The narrow anterior part of the cricoid cartilage is on a level with the disc between the bodies of the fifth and sixth cervical vertebræ, at which level the pharynx terminates in the œsophagus. In this situation a foreign body, when swallowed, is liable to become impacted.

Above the middle third of the clavicle, between the sterno-cleido-mastoid and trapezius muscles, there is a depression known as the supraclavicular fossa, which indicates the position of the subclavian or supraclavicular triangle, with the third part of the subclavian artery and the trunks of the brachial plexus of nerves.

Platysma Myoides—*Origin.*—The superficial fascia which covers the clavicular parts of the pectoralis major and deltoid muscles.

Insertion.—(1) The outer aspect of the base of the inferior maxilla from the symphysis to the anterior border of the masseter muscle ; and (2) the angle of the mouth, where the fibres blend with those of the depressor anguli oris and orbicularis oris.

Nerve-supply.—The inframandibular (cervical) branch of the cervico-facial division of the facial nerve, which communicates with branches of the superficial cervical nerve.

The fibres are directed upwards and forwards or inwards over the clavicle and side of the neck.

Action.—(1) To draw the angle of the mouth downwards and outwards ; (2) to act as a feeble depressor of the inferior maxilla ; (3) to raise the skin of the neck and upper pectoral region, as far out as the acromion process, throwing it into obliquely-disposed folds. By diminishing pressure upon the external jugular vein during forced inspiration the muscle contributes to the return of blood through that vessel.

The muscle forms an extensive, thin, pale sheet, which is embedded within the superficial fascia. In the region of the symphysis of the inferior maxilla the innermost fibres decussate across the middle line with those of the opposite side, the fibres of the right muscle being superficial. The muscle covers the external and anterior jugular veins, the superficial branches of the cervical plexus of nerves, the subclavian triangle, and the sterno-cleido mastoid, sterno-hyoid, omo-hyoid, and digastric muscles.

The platysma myoides in man is a remnant of a subcutaneous muscular sheet, called the *panniculus carnosus*, which exists in many animals, and by which the twitching of the skin is produced.

Jugular Veins.—The jugular veins are four in number on either side, namely, anterior, external, posterior, and internal.

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The **anterior jugular vein** commences in the roof of the submaxillary or digastric triangle, where it is formed by the union of radicles which communicate with the submental vein, and are joined by radicles which have descended from the structures over the body of the inferior maxilla. It descends vertically near the median line, lying at first superficial to the deep cervical fascia, but sub-

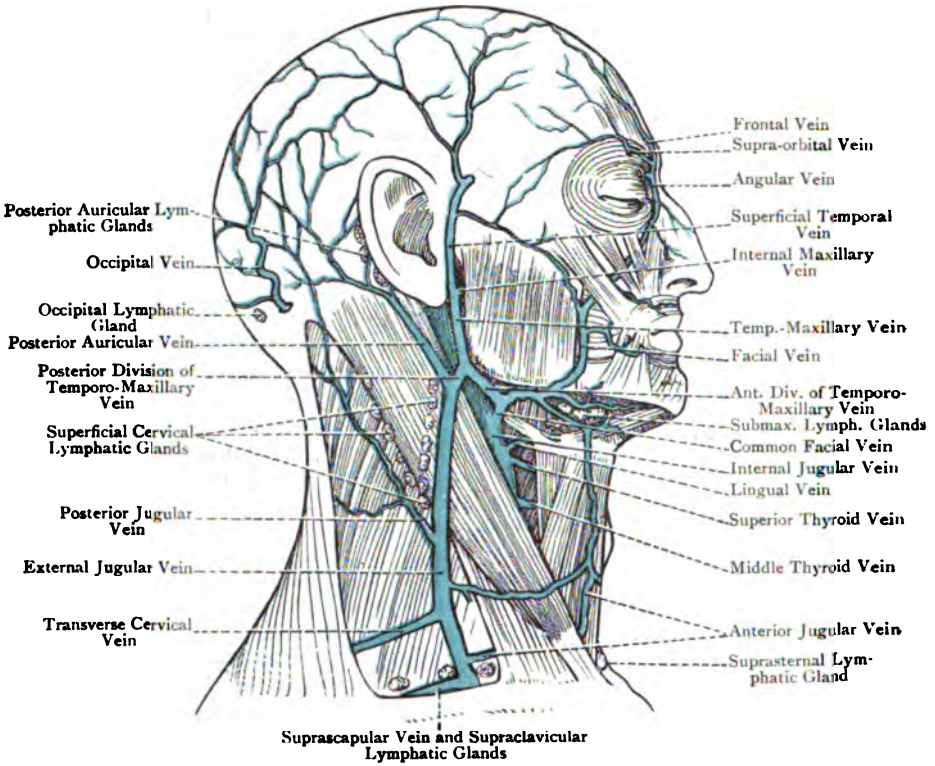

FIG. 424.—THE SUPERFICIAL VEINS AND SUPERFICIAL LYMPHATIC GLANDS OF THE RIGHT SIDE OF THE HEAD AND NECK.

(The Platysma Myoides Muscle has been removed).

sequently entering the suprasternal interfascial space, or space of Burns. It then describes a bend, and, passing outwards behind the sterno-cleido-mastoid muscle, and in front of the scalenus anticus, it opens into the lower part of the external jugular vein. It may, however, open into the subclavian vein. It communicates with the external jugular vein by one or more branches, and it usually receives a branch from the facial vein which descends along the anterior

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border of the sterno-cleido-mastoid and joins it towards the lower part of the neck. Further, it communicates with its fellow of the opposite side by a transverse branch which crosses in front of the trachea, and lies in Burns's space.

The anterior jugular veins are usually asymmetrical, one or other being of small size. Occasionally there is only one vein, which is mesially placed, and, under these circumstances, it divides into two vessels inferiorly. The anterior jugular vein is destitute of valves.

The **external jugular vein** commences close behind the angle of the inferior maxilla in the substance of the parotid gland, where it is formed by the union between the posterior division of the temporo-maxillary vein and the posterior auricular vein. Having emerged from the parotid gland it descends almost vertically to a point above the centre of the clavicle. In its course the vessel crosses the sterno-cleido-mastoid muscle, lying superficial to its sheath, and beneath the superficial fascia containing the fibres of the platysma myoides. At this level the main part of the superficial cervical nerve courses forwards beneath the vein, and offsets of the nerve pass over it. Having crossed the sterno-cleido-mastoid muscle, the vein descends not far from its posterior border, where it lies in the roof of the subclavian or supraclavicular triangle, over the third part of the subclavian artery. Up to this point the vessel is superficial to the deep cervical fascia, but it now pierces that fascia and opens into the subclavian vein.

The course of the external jugular vein is indicated by a line drawn from a point close behind the angle of the inferior maxilla to a point above the centre of the clavicle. Its tributaries are as follows: (1) posterior jugular, which joins it about the middle of the neck; (2) transverse cervical; (3) suprascapular; and (4) anterior jugular, the latter three joining it not far from its termination. It also communicates with the anterior jugular vein by one or more branches. The vessel is provided with valves, both at its termination and about 1½ inches above this point, and the transverse cervical and suprascapular veins are also furnished with valves, where they open into the external jugular vein, or near their orifices.

The external jugular vein is sometimes very small, or even absent; and it may communicate with the cephalic vein by a vessel which passes over the clavicle.

Development.—The external jugular vein is usually regarded as being developed from the primitive jugular vein; but according to some authorities the primitive jugular vein gives rise to the internal jugular vein, the external jugular being of later development.

The **posterior jugular vein** represents the most external occipital vein, and is formed by tributaries which issue from the outer part of the occipital plexus, reinforced by veins from the superficial structures at the back of the neck. Having usually received the mastoid emissary vein, it passes downwards and forwards, and joins the external jugular vein about the middle of the neck.

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The internal jugular vein will be found described on p. 1038.

Superficial Cervical Glands.—These are about six in number, and they lie upon the sterno-cleido-mastoid muscle, along the course of the external jugular vein, and beneath the superficial fascia and platysma myoides muscle. They receive their afferent lymphatics from the adjacent superficial structures, the occipital and mastoid glands, and some of those of the parotid and submaxillary lymphatic glands. Their efferent lymphatics pass to the deep cervical and supraclavicular glands.

Deep Cervical Fascia.—The deep cervical fascia is divided into (1) a superficial layer, which completely invests the neck in the form of a collar, and (2) deep processes or laminæ, which invest the muscles, viscera, and chief bloodvessels and nerves.

Superficial Layer.—This layer is attached posteriorly to the ligamentum nuchæ; superiorly to (1) the superior curved line of the occipital bone; (2) the mastoid process of the temporal bone; (3) the zygomatic arch; and (4) the base of the inferior maxilla, under cover of the platysma myoides, as far forwards as the symphysis; and inferiorly to the clavicle and upper border of the manubrium sterni, being pierced above the centre of the clavicle by the external jugular vein. Along the middle line of the neck anteriorly it is continuous with the superficial layer of the opposite side.

The superficial layer invests the cervical portion of the trapezius, and from the anterior border of that muscle it passes forwards over the posterior triangle of the neck to the posterior border of the sterno-cleido-mastoid. In doing so it furnishes a deep process, which ensheathes the posterior belly of the omo-hyoid muscle. This process also embraces the intervening tendon of that muscle, after which it passes downwards and inwards to be attached to the back of the inner end of the clavicle and the first rib. In this manner the horizontal position of the posterior belly of the omo-hyoid is accounted for. When the superficial layer of the deep cervical fascia reaches the posterior border of the sterno-cleido-mastoid it splits into two laminæ which ensheathe that muscle, the superficial lamina being underneath the external jugular vein and platysma myoides. At the anterior border of the sterno-cleido-mastoid the two laminæ reunite, and the fascia passes forwards over the anterior triangle of the neck to the median line, where it is continuous with the corresponding layer of the opposite side.

Between the upper part of the anterior border of the sterno-cleido-mastoid and the angle of the inferior maxilla the superficial layer is of considerable strength, and draws that border of the muscle forwards and upwards, so as to render it convex and keep it over the line of the leading vessels. Between the mastoid process and the angle of the inferior maxilla the superficial layer is prolonged upwards over the parotid gland as the parotid fascia, which is very dense, and is attached superiorly to the lower border of the zygomatic arch.

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Below the level of the thyroid body the superficial layer divides into two laminæ, anterior and posterior, both of which are superficial to the depressor muscles of the hyoid bone. At the middle line these laminæ are continuous with those of the opposite side, and inferiorly they are attached to the anterior and posterior margins of the upper border of the manubrium sterni. Between them there is an interfascial interval, called the **suprasternal space,** or **space of Burns.** This interval contains areolar tissue, one or more lymphatic glands, the lower portions of the anterior

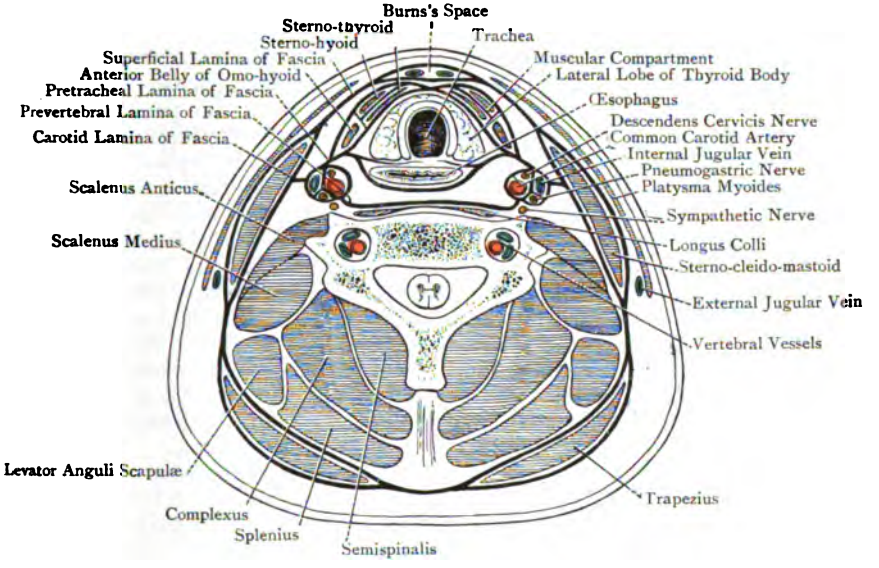

FIG. 425.—DIAGRAM OF A TRANSVERSE SECTION OF THE NECK AT THE LEVEL OF THE SEVENTH CERVICAL VERTEBRA, SHOWING THE ARRANGEMENT OF THE DEEP CERVICAL FASCIA, AND THE POSITIONS OF OTHER STRUCTURES.

jugular veins, with the transverse vessel which here connects them, and the sternal heads of the sterno-cleido-mastoid muscles.

Deep Processes or Laminæ.—The deep laminæ, as stated, invest the muscles, viscera, and chief bloodvessels and nerves. The most important are derived from that lamina of the superficial layer which forms the posterior wall of the sheath of the sterno-cleido-mastoid muscle, and they are three in number, namely, carotid, pretracheal, and prevertebral, all of which have an intimate initial connection.

The **carotid lamina** splits to form the carotid sheath, which contains, in separate compartments (1) the common carotid artery and descendens cervicis nerve, (2) the internal jugular vein, and (3) the

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pneumogastric nerve, the latter being contained within the back part of the septum, which separates the artery from the vein.

The **pretracheal** or **visceral lamina,** which is at first intimately connected with the anterior wall of the carotid sheath, passes forwards behind the depressor muscles of the hyoid bone, in which situation it splits to ensheathe the thyroid body, trachea, and œsophagus, and then it passes to the median line, where it is continuous with the pretracheal lamina of the opposite side. The pretracheal lamina is attached superiorly to the body of the hyoid bone, and inferiorly it descends over the trachea and bloodvessels into the superior mediastinum of the thorax, where it blends with the fibrous layer of the pericardium.

The **prevertebral lamina,** which is at first intimately connected with the posterior wall of the carotid sheath, passes forwards behind the pharynx and œsophagus, and in front of the prevertebral muscles. It is known as the *prevertebral fascia.* At the middle line it is continuous with the corresponding lamina of the opposite side; superiorly it is attached to the base of the skull; and inferiorly it descends over the longus colli muscle into the posterior mediastinum of the thorax. Along a line corresponding to the inner wall of the carotid sheath the pretracheal lamina furnishes a secondary lamina, called the **bucco-pharyngeal fascia,** which covers the constrictor muscles of the pharynx and the buccinator muscle. Between the bucco-pharyngeal and prevertebral fasciæ there is an interval, called the **retro-pharyngeal space,** which contains the loosely arranged connective tissue uniting the two fasciæ. This space extends as high as the base of the skull, and inferiorly is continuous with the posterior mediastinum of the thorax. Another process of the prevertebral fascia passes downwards and outwards in front of the scalenus anticus muscle. Thereafter it invests the third part of the subclavian artery and subclavian vein, together with the nerve-trunks of the brachial plexus, and, passing behind the clavicle, it becomes continuous with the axillary sheath, which latter blends with the posterior aspect of the costo-coracoid membrane. In the region of the subclavian triangle there is an interfascial space between this process of the pretracheal fascia and the superficial layer of the deep cervical fascia. This space extends downwards behind the clavicle to the point where the axillary sheath and costo-coracoid membrane join. It contains the posterior belly of the omo-hyoid muscle, the suprascapular and transverse cervical vessels, the lower part of the external jugular vein, and the terminal portion of the anterior jugular vein.

Interfascial Compartments. — It has been stated that the deep cervical fascia reaches the median line of the neck anteriorly in three layers, namely, anterior or superficial in (two divisions), pretracheal, and prevertebral. It is therefore evident that there are four interfascial compartments, as follows: (1) the **suprasternal space,** or **space of Burns,** which is situated between the two divisions of the anterior or superficial layer, and contains the structures

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already enumerated ; (2) the **muscular compartment,** which is situated between the anterior or superficial layer and the pretracheal layer, and contains the depressor muscles of the hyoid bone ; (3) the **visceral compartment,** which lies between the pretracheal and prevertebral layers, and contains the larynx, trachea, thyroid body, pharynx, œsophagus, and carotid sheath, the retro-pharyngeal space being in the subdivision of this compartment behind the bucco-pharyngeal fascia; and (4) the **vertebral compartment,** which lies between the prevertebral layer and the attachment of the fascia to the ligamentum nuchæ posteriorly, and contains the vertebral column, spinal cord, and prevertebral and postvertebral muscles.

The suprasternal and muscular compartments are shut off from the thoracic cavity. The visceral compartment, in front of the trachea, is continuous with the superior mediastinum of the thorax, and behind the œsophagus it, along with the retro-pharyngeal space, is continuous with the posterior mediastinum.

Parotid Process of the Deep Cervical Fascia.—This process is given off a little below the angle of the inferior maxilla, and it passes upwards on the deep surface of the parotid gland to the skull. Along with the parotid fascia superficial to the gland it forms a dense sheath which closely invests the glandular substance. The parotid process furnishes sheaths to the posterior belly of the digastric, styloid, and pterygoid muscles, and it also gives an investment to the superficial part of the submaxillary gland. Connected with the parotid process there are several bands, usually called ligaments, which are as follows : (1) spheno-mandibular ; (2) stylo-mandibular ; (3) pterygo-mandibular ; and (4) pterygo-spinous.

The **spheno-mandibular ligament** will be described in connection with the temporo-mandibular joint, of which it ranks as the internal lateral ligament.

The **stylo-mandibular ligament** extends from the styloid process of the temporal bone, near its tip, to the angle and adjacent part of the posterior border of the ramus of the inferior maxilla, where it is placed between the masseter and internal pterygoid muscles.

The **pterygo-mandibular ligament** is a narrow band which extends from the hamular process of the internal pterygoid plate of the sphenoid bone to the posterior extremity of the mylo-hyoid ridge of the inferior maxilla, close to the last molar alveolus. Anteriorly it gives origin to fibres of the buccinator muscle, and posteriorly to fibres of the superior constrictor muscle of the pharynx.

The **pterygo-spinous ligament** is a narrow band which extends from a sharp spine on the posterior border of the external pterygoid plate of the sphenoid bone, towards its upper part, to the spinous process of the sphenoid. This ligament is liable to become ossified.

Sterno-cleido-mastoid — *Origin.*—The **sternal head,** which is narrow and round, arises from the upper and outer part of the anterior surface of the manubrium sterni. It is tendinous in front,

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and fleshy behind. The **clavicular head,** which is broad and flat arises from a rough ridge about 1½ inches long on the upper surface of the clavicle at its inner end, near the postero-superior border.

Insertion.—(1) The outer surface of the mastoid process of the temporal bone, and (2) the superior curved line of the occipital bone over about its outer half or two-thirds.

Nerve-supply.—(1) The spinal portion of the spinal accessory nerve, and (2) a branch from the cervical plexus, more particularly from the anterior primary division of the second cervical nerve.

The spinal portion of the spinal accessory nerve passes beneath the anterior border of the muscle fully 1 inch below the tip of the mastoid process, and, in passing downwards and backwards, it pierces the deep part of the muscle, giving off, as it does so, its branches to it.

The muscle is directed upwards, outwards, and backwards.

Action.—(1) To flex the head towards the side on which the muscle is placed, the face being turned towards the opposite side. This is the position of the head in *torticollis* or *wry-neck*, a condition which may be due to an organic contraction of the muscle, affecting both heads, or, it may be, the sternal head alone. (2) When both muscles act together from their origin they flex the head towards the thorax. (3) When both muscles act together from their insertion they elevate the upper part of the anterior thoracic wall in forced inspiration.

The sternal and clavicular heads are separated by a triangular cellular interval for a short distance above the sterno-clavicular joint, and before their junction the fibres of the clavicular head to a large extent pass behind those of the sternal head, so that overlapping takes place. The muscle is surrounded by a strong sheath, which is formed by the deep cervical fascia. The platysma myoides covers a large part of it, and the external jugular vein, the superficial cervical and great auricular nerves, and the superficial cervical glands are related to its superficial surface, under cover of the platysma myoides. The principal deep relations are as follows: in the lower part of the neck it covers the first and second parts of the subclavian artery, the sterno-hyoid, sterno-thyroid, omo-hyoid, and scalenus anticus muscles, with the phrenic nerve lying upon the last-named muscle. In this situation it also covers the anterior jugular vein, and the transverse cervical and suprascapular arteries. Higher up it covers the cervical plexus of nerves, the levator anguli scapulæ, scalenus medius, and scalenus posticus muscles, and the spinal portion of the spinal accessory and the hypoglossal nerves. At its insertion it covers the splenius capitis, trachelo-mastoid, and posterior belly of the digastric muscles, and a portion of the occipital artery, in this order from the surface downwards. The anterior border of the muscle forms the posterior boundary of the anterior triangle of the neck, and covers the carotid sheath, with its contents, as high as the level of the upper border of the thyroid cartilage; and above that level it covers the

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external and internal carotid arteries. This border also overlaps slightly the lateral lobe of the thyroid body. The posterior border forms the anterior boundary of the posterior triangle of the neck, and along it there lie the following structures: the glandulæ concatenatæ, the small occipital nerve, great auricular, superficial cervical, spinal portion of the spinal accessory, and the descending superficial branches of the cervical plexus of nerves, and a portion of the external jugular vein.

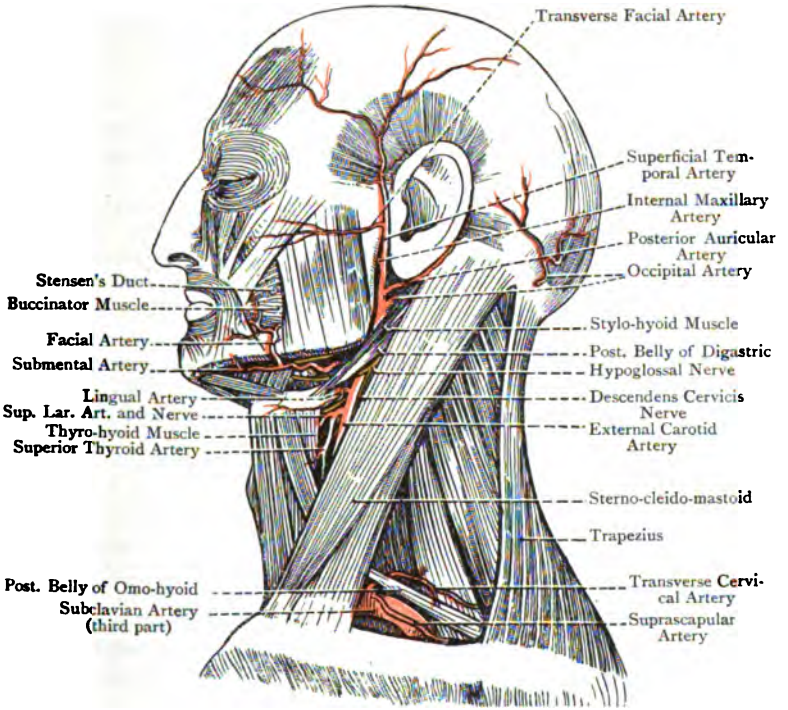

FIG. 426.—THE LEFT SIDE OF THE HEAD AND NECK.

(The Platysma Myoides has been removed).

The sterno-cleido-mastoid muscle, from its diagonal position upon the side of the neck, divides the quadrilateral space into two triangles—posterior and anterior.

Posterior Triangle.—This is the region which lies behind the sterno-cleido-mastoid muscle.

Boundaries—*Anterior.*—The posterior border of the sterno-cleido-mastoid. *Posterior.*—The anterior border of the trapezius. *Inferior* (**base**).—The middle third of the clavicle. The **apex** is at

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the superior curved line of the occipital bone, where the sterno-cleido-mastoid and trapezius may meet, but the apex is usually truncated. The **roof** is formed by the skin, superficial and deep fasciæ, and, for a short distance inferiorly, by the platysma myoides. The small occipital nerve lies in the upper part of the roof, and the descending superficial branches of the cervical plexus and the external jugular vein lie in the lower part of the roof. The **floor** is formed by the following muscles, in order from above downwards : (1) a small angle of the complexus, provided the trapezius is not well developed at the occiput ; (2) the splenius capitis ; (3) the levator anguli scapulæ ; (4) the scalenus medius and scalenus posticus ; (5) the posterior belly of the omo-hyoid ; and (6) the scalenus anticus.

The posterior triangle is subdivided by the posterior belly of the omo-hyoid into a large upper portion, called the occipital triangle, and a small lower portion, called the subclavian or supraclavicular triangle.

Occipital Triangle—Boundaries—*Anterior.*—The posterior border of the sterno-cleido-mastoid. *Posterior.*—The anterior border of the trapezius. *Inferior* (**base**).—The posterior belly of the omo-hyoid. The muscles in its floor are (1) a small angle of the complexus (inconstant), (2) splenius capitis, (3) levator anguli scapulæ, and (4) scaleni medius et posticus. The **contents** are the superficial branches of the cervical plexus, the spinal accessory nerve, the branches of the cervical plexus to the levator anguli scapulæ and trapezius, a small part of the occipital artery close to the apex, and the glandulæ concatenatæ.

Cervical Plexus.—The cervical plexus is situated under cover of the upper part of the sterno-cleido-mastoid muscle, and lies immediately in front of the slips of origin of the scalenus medius. It is formed by the anterior primary divisions of the first three cervical nerves and the greater part of that of the fourth, a small branch of the latter descending to join the anterior primary division of the fifth, and so taking part in the brachial plexus. Each of the anterior primary divisions of the first four cervical nerves is connected with the superior cervical ganglion of the sympathetic by a grey ramus communicans.

The *anterior primary division of the first cervical nerve* lies at first in the vertebrarterial groove of the atlas under cover of the vertebral artery. It then passes forwards in a groove on the outer surface of the superior articular process of the atlas, having the vertebral artery on its outer side. It next emerges between the rectus capitis lateralis muscle (to which it gives a branch) and the rectus capitis anticus minor, and descends in front of the root of the costal process of the atlas to join the ascending branch of the second nerve. From the loop so formed branches are given to the recti antici muscles, major and minor, and one or more branches pass to the hypoglossal nerve, the destination of their fibres being the descendens cervicis and thyro-hyoid nerves.

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The *anterior primary divisions of the second, third, and fourth cervical nerves*, having emerged between the corresponding intertransversales muscles, divide each into an ascending and a descending branch, which unite with adjacent branches to form loops. The descending branch of the fourth nerve, as stated, joins the fifth, and enters into the brachial plexus. The cervical plexus is therefore a looped plexus, the number of loops being three.

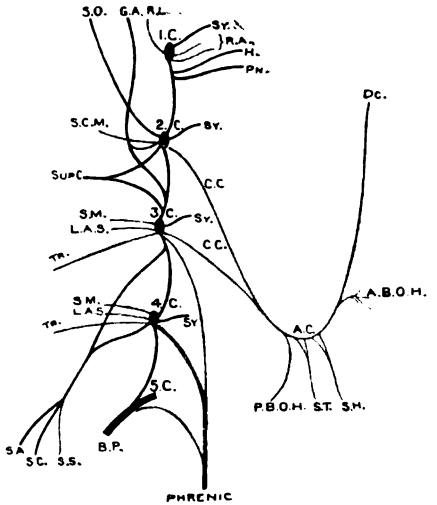

FIG. 427.—SCHEME OF THE CERVICAL PLEXUS OF NERVES.

The Descendens Cervicis Nerve is also shown.

1c, 2c, 3c, 4c, 5c. } Anterior Primary Divisions of Upper Five Cervical Nerves
R.L. To Rectus Lateralis
G.A. Great Auricular
S.O. Small Occipital
S.C.M. To Sterno-cleido-mastoid
Sup.C. Superficial Cervical
S.M., S.M. To Scalenus Medius
L.A.S., L.A.S. } To Levator Anguli Scapulæ
TR., TR. To Trapezius
S.A. Supra-acromial
S.C. Supraclavicular
S.S. Suprasternal
SY. Branches to Sympathetic
R.A. To Rectus Capitis Anticus Major et Minor
H. To Hypoglossal
PN. To Pneumogastric (Ganglion of Trunk)
C.C., C.C. Communicantes Cervicis
D.C. Descendens Cervicis
A.B.O.H. To Anterior Belly of Omo-hyoid
A.C. Ansa Cervicis
S.H. To Sterno-hyoid
S.T. To Sterno-thyroid
P.B.O.H. To Posterior Belly of Omo-hyoid

Branches.—These are divided into two groups—superficial and deep.

Superficial Group.—The nerves of this group are ascending, transverse, and descending.

The ascending and transverse nerves arise from the second and third cervical nerves.

The *ascending nerves* are the small occipital and great auricular (see p. 984). The *transverse nerve* is the superficial (transverse) cervical.

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The **superficial** or **transverse cervical nerve** arises by two roots from the anterior primary divisions of the second and third cervical nerves, and, turning round the posterior border of the sterno-cleido-mastoid muscle, it passes forwards over the muscle, lying beneath the platysma myoides and the external jugular vein. Having reached the anterior triangle of the neck, it divides into two branches, upper and lower, which are distributed to the integument over the anterior triangle. The offsets of the upper branch communicate freely with the inframandibular branch of the facial nerve beneath the platysma myoides.

The *descending nerves* are the suprasternal, supraclavicular, and supra-acromial, and they arise in common from the third and fourth cervical nerves. As they descend they form distinct nerves, which lie in the roof of the subclavian triangle under cover of the platysma myoides. For their distribution, see p. 279.

Deep Group.—The nerves of this group are arranged in two sets—external and internal.

External Set.—The nerves of this set are muscular. (1) The second nerve furnishes a branch to the sterno-cleido-mastoid, which communicates in that muscle with the branch of the spinal portion of the spinal accessory nerve. (2) The third and fourth nerves furnish (*a*) two branches to the trapezius, which communicate in a plexiform manner with the spinal portion of the spinal accessory nerve beneath the upper part of the muscle; (*b*) two branches to the levator anguli scapulæ; and (*c*) branches to the scalenus medius.

Internal Set.—The nerves of this set are communicating and muscular.

The *communicating branches* are as follows: (1) connecting branches (grey rami communicantes) pass from the upper cervical ganglion of the sympathetic; (2) communicating branches pass to the pneumogastric and hypoglossal nerves from the highest loop of the plexus; and (3) two rami communicantes cervicis pass from the second and third nerves forwards and downwards, usually over, but sometimes underneath, the internal jugular vein, and terminate by joining the descendens cervicis, conjointly or separately, thus forming the ansa cervicis (ansa hypoglossi).

The *muscular branches* are distributed to the rectus capitis lateralis, recti antici, major and minor, upper part of the scalenus anticus, longus colli, and the diaphragm. The nerve to the diaphragm is the phrenic nerve (internal respiratory nerve), and, from its importance, it requires a special description.

The phrenic nerve arises, as a rule, by two roots, the larger of which is derived from the anterior primary division of the *fourth* cervical nerve, and the other from that of the third. In some cases the fifth cervical nerve, which enters into the brachial plexus, furnishes an additional small root. In the neck the nerve descends upon the scalenus anticus muscle, which it crosses obliquely downwards and inwards, passing beneath the tendon of the omo-hyoid muscle, the transverse cervical and supra-

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scapular arteries, and the anterior jugular vein. At the root of the neck the nerve, having left the scalenus anticus, passes behind the terminal part of the subclavian vein, and crosses *over* the internal mammary artery from without inwards. Having come into contact with the inner surface of the dome of the pleura, it disappears behind the inner end of the clavicle, and enters upon the thoracic part of its course (see p. 885).

The *right* nerve at the root of the neck is superficial to the second part of the right subclavian artery, with the intervention of the scalenus anticus muscle. The *left* nerve at the root of the neck is anterior and parallel to the first part of the left subclavian artery, and lies behind the terminal part of the thoracic duct.

The phrenic nerve is sometimes reinforced towards the root of the neck by a branch from the nerve to the subclavius muscle, and, when this takes place, the root from the fifth cervical nerve is usually absent. Before leaving the neck the phrenic nerve receives a twig from the middle, or lower, cervical ganglion of the sympathetic.

No branches arise from the phrenic nerve in the neck.

Suprascapular Glands.—These are three or four in number, and are situated over the subclavian triangle. They are continuous superiorly with the glandulæ concatenatæ, and inferiorly with the external axillary glands. They receive their afferent lymphatics from the adjacent parts of the neck, the acromial region, the lower superficial cervical glands, the upper part of the pectoral region, and, it may be, from the upper part of the mammary gland. Their efferent lymphatics pass to the jugular lymphatic trunk.

Subclavian or Supraclavicular Triangle.—The subclavian triangle is the lower division of the posterior triangle of the neck, and is separated from the upper division, or occipital triangle, by the posterior belly of the omo-hyoid muscle. It is situated above the middle third of the clavicle, and is of small size until the deep cervical fascia, which ensheathes the posterior belly of the omo-hyoid, has been divided.

Boundaries—*Superior.*—The posterior belly of the omo-hyoid muscle. *Inferior.*—The middle third of the clavicle. *Anterior.*—The clavicular part of the sterno-cleido-mastoid muscle. *Roof.*—The skin ; superficial fascia and platysma myoides muscle ; supra-sternal, supraclavicular, and supra-acromial nerves ; a part of the external jugular vein ; and the deep cervical fascia. *Floor.*—The scalenus medius and scalenus posticus muscles.

The extent of the triangle is affected by (1) the height to which the posterior belly of the omo-hyoid ascends above the clavicle, and (2) the extent of the clavicular attachments of the sterno-cleido-mastoid and trapezius muscles. The depth of the triangle is influenced by the position of the shoulder, being greater when the shoulder is raised and carried forwards, and less when it is depressed and carried backwards.

Contents.—The contents are as follows : (1) the greater portion of the third part of the subclavian artery ; (2) small portions of the

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transverse cervical artery and vein ; (3) the lower portion of the external jugular vein ; (4) the nerve-trunks of the brachial plexus ; and (5) the nerve to the subclavius muscle, and the supra-scapular and posterior thoracic nerves.

Third Part of the Subclavian Artery.—This part of the vessel extends from the outer border of the scalenus anticus muscle to the outer border of the first rib, where it becomes the axillary artery. Its course is downwards and outwards, and, for the greater part of its extent, it lies in the subclavian triangle. Subsequently, however, it passes under cover of the clavicle and subclavius muscle.

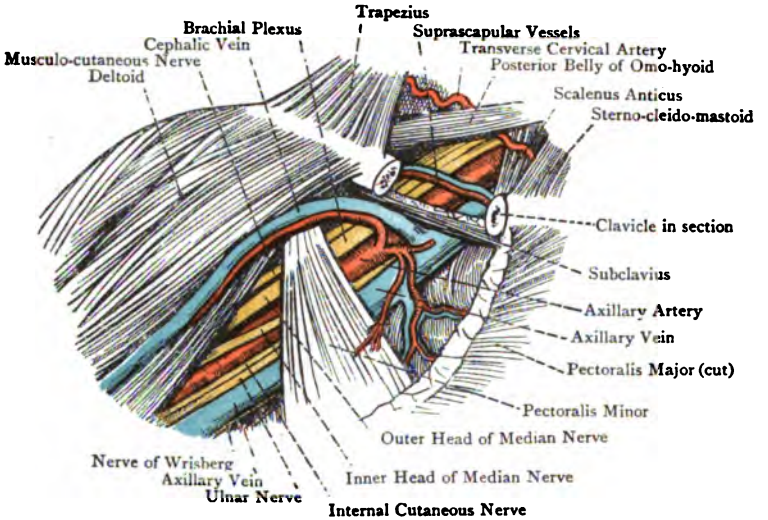

FIG. 428.—THE AXILLARY SPACE, AFTER REFLECTION OF THE PECTORALIS MAJOR; AND THE SUBCLAVIAN TRIANGLE.

Relations—*Anterior.*—The skin; superficial fascia and platysma myoides ; suprasternal, supraclavicular, and supra-acromial nerves ; deep cervical fascia ; clavicle and subclavius muscle ; transverse cervical vessels ; suprascapular vessels ; nerve to the subclavius muscle ; and the terminal portion of the external jugular vein. The last-named vessel crosses in front of the artery close to the sterno-cleido-mastoid muscle, and in this situation is joined by the transverse cervical and suprascapular veins. A plexiform arrangement of veins is sometimes met with over the artery, which may be rendered more complex by a branch ascending over the clavicle from the cephalic vein. *Posterior.*—The scalenus medius, with the close intervention of the lower nerve-trunk of the brachial plexus. *Superior.*—The upper and middle nerve-trunks of the brachial plexus, the latter being nearest the vessel. *Inferior.*—

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The upper surface of the first rib and the subclavian vein, the vein being on a more anterior plane than the artery, and lying behind the clavicle.

The third part of the subclavian artery does not usually furnish any branch. In some cases, however, the *posterior scapular artery* arises from it, instead of from the transverse cervical branch of the thyroid axis from the first part of the subclavian. In these cases the posterior scapular artery passes outwards between the nerve-trunks of the brachial plexus.

The **direction** of the third part of the artery is indicated by a line drawn from a point on the posterior border of the sterno-cleido-mastoid muscle, about ½ inch above the clavicle, to the centre of that bone. The artery is accessible to compression as it passes over the first rib, the guide to it at this point being the centre of the clavicle. In ligation of the artery the guide to it is the scalene tubercle or spine (tubercle of Lisfranc) on the inner border of the first rib, behind which tubercle the vessel lies; and the scalenus anticus muscle, which is usually covered by the clavicular part of the sterno-cleido-mastoid, leads to this tubercle.

For the manner in which the collateral circulation is carried on after ligation of the third part of the subclavian artery, see p. 304.

The **subclavian vein,** in the region of the subclavian triangle, is situated behind the clavicle, where it lies below and anterior to the artery. On the upper surface of the first rib it is anterior to the scalenus anticus, and it receives the external jugular vein, and in some cases the anterior jugular vein.

The **transverse cervical artery** lies in the subclavian triangle for a short distance only, close to where the posterior belly of the omo-hyoid passes beneath the sterno-cleido-mastoid. It passes outwards beneath the former muscle into the lower part of the occipital triangle, where it divides into its superficial cervical and posterior scapular branches, the former entering the trapezius, and the latter passing beneath the levator anguli scapulæ, after which it descends along the base of the scapula, under cover of the rhomboid muscles.

The **transverse cervical vein** opens into the external jugular vein, there being a valve at, or near, its ending.

The **suprascapular artery** is not in the subclavian triangle, but lies behind the clavicle, close to its upper aspect. It will be described in connection with the first part of the subclavian artery (see p. 1067).

The **suprascapular vein** also lies behind the clavicle, and it opens into the external jugular vein, there being a valve at, or near, its ending.

The external jugular vein will be found described on p. 1009.

Brachial Plexus.—The brachial plexus is situated in the lower part of the posterior triangle of the neck, behind the clavicle, and in the upper part of the axilla. Its complex formation is rendered simple by arranging it into four stages, namely (1) nerve-roots, (2) nerve-trunks, (3) divisions of nerve-trunks, and (4) nerve-cords.

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First Stage.—The nerves which form the plexus are the anterior primary divisions of the fifth, sixth, seventh, and eighth cervical, and the greater part of that of the first thoracic. Superiorly the plexus is reinforced by a small descending branch from the fourth cervical, which joins the fifth, and inferiorly it is occasionally reinforced by a branch from the second thoracic, which joins the first. As regards the first thoracic nerve, the part of it which does not join the plexus, and which is of small size, enters the first intercostal space to become the first intercostal nerve. The nerves, as they

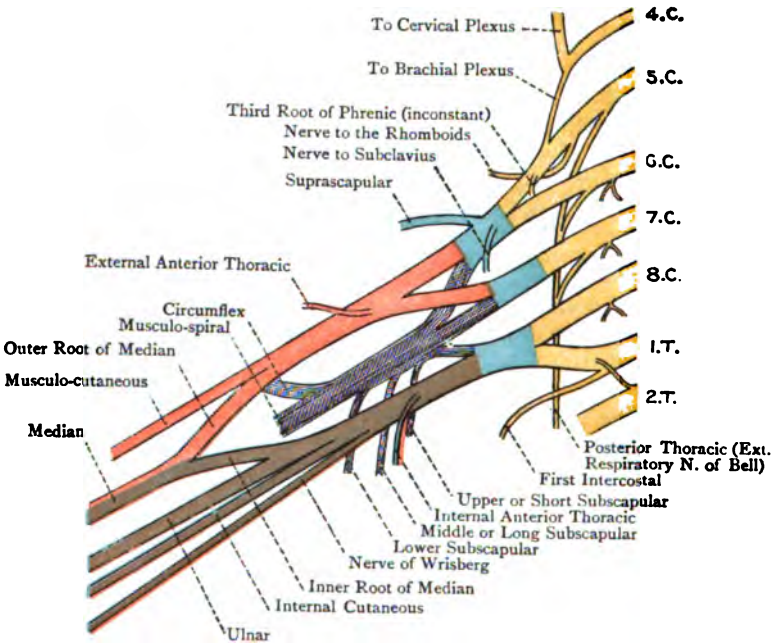

FIG. 429.—THE BRACHIAL PLEXUS.

(Yellow = Spinal Nerves and their Branches; Blue = Trunks; Red = Outer Cord; Purple = Inner Cord; Grey = Posterior Cord.)

emerge at the side of the neck, are placed between the scalenus anticus and scalenus medius.

Second Stage.—The fifth and sixth cervical nerves join at the outer border of the scalenus anticus to form the **upper trunk**; the seventh cervical remains meanwhile single, and forms the **middle trunk**; and the eighth cervical and greater part of the first thoracic unite between the scalene muscles to form the **lower trunk.** There are thus three trunks—upper, middle, and lower.

Third Stage.—A little above the clavicle each of the three trunks breaks up into an anterior and a posterior division.

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Fourth Stage.—The anterior divisions of the upper and middle trunks unite to form the **outer cord** of the plexus; the anterior division of the lower trunk, which is of large size, forms the **inner cord**; and all three posterior divisions (that of the lower trunk being of small size) unite to form the **posterior cord.** As a variety, the anterior division of the middle trunk may subdivide into two branches, one entering the outer cord and the other the inner. There are thus three cords—outer, inner, and posterior.

Branches of the Plexus.—The branches are conveniently divided into two groups—supraclavicular, arising above the clavicle, and coming from nerve-roots and nerve-trunks; and infraclavicular, arising below the clavicle, and coming from nerve-cords.

Supraclavicular Branches.—These are as follows: **Muscular branches** from the four cervical nerves to the scalene muscles and longus colli.

One root of the phrenic nerve (inconstant) from the front of the fifth cervical.

The Nerve to the Rhomboids.—This branch arises from the back of the fifth cervical, close to or along with the highest root of the posterior thoracic, and it takes a backward course through the scalenus medius.

The Posterior Thoracic Nerve or External Respiratory Nerve of Bell.—This branch arises by three roots from the back of the fifth, sixth, and seventh cervical nerves. The upper two roots pierce the scalenus medius muscle below the nerve to the rhomboids, either conjointly or separately, whilst the lowest root passes in front of the scalenus medius, and joins the trunk formed by the others near the first rib. The nerve then courses behind the brachial plexus and the first part of the axillary artery to the axillary surface of the serratus magnus, which it supplies.

The Nerve to the Subclavius.—This small branch arises from the front of the upper trunk, its fibres being derived from the fifth cervical. It descends over the third part of the subclavian artery, and, passing behind the clavicle, it enters the subclavius muscle on its deep aspect. This nerve sometimes communicates with the phrenic nerve.

The Suprascapular Nerve.—This is a large nerve which arises from the back of the upper trunk, its fibres being derived from the fifth and sixth cervical. It is directed downwards, outwards, and backwards beneath the trapezius and posterior belly of the omo-hyoid to the upper border of the scapula, on approaching which it gets in company with the suprascapular artery. It is distributed to the supraspinatus and infraspinatus muscles and shoulder-joint.

For the infraclavicular branches of the brachial plexus, see p. 294.

Anterior Triangle.—This triangle is situated in front of the sterno-cleido-mastoid muscle, and its base is directed upwards.

Boundaries—*Anterior.*—The middle line of the neck, that is to say, a line extending from the chin to the upper border of the manubrium sterni. *Posterior.*—The anterior border of the sterno-

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cleido-mastoid muscle. *Superior.*—One half of the base of the inferior maxilla, and a line drawn from the angle of that bone to the mastoid process. The triangle is covered by the skin, superficial cervical fascia, platysma myoides, and deep cervical fascia. Superficial to the deep fascia there are the following structures: the anterior jugular vein, the ramifications of the superficial or

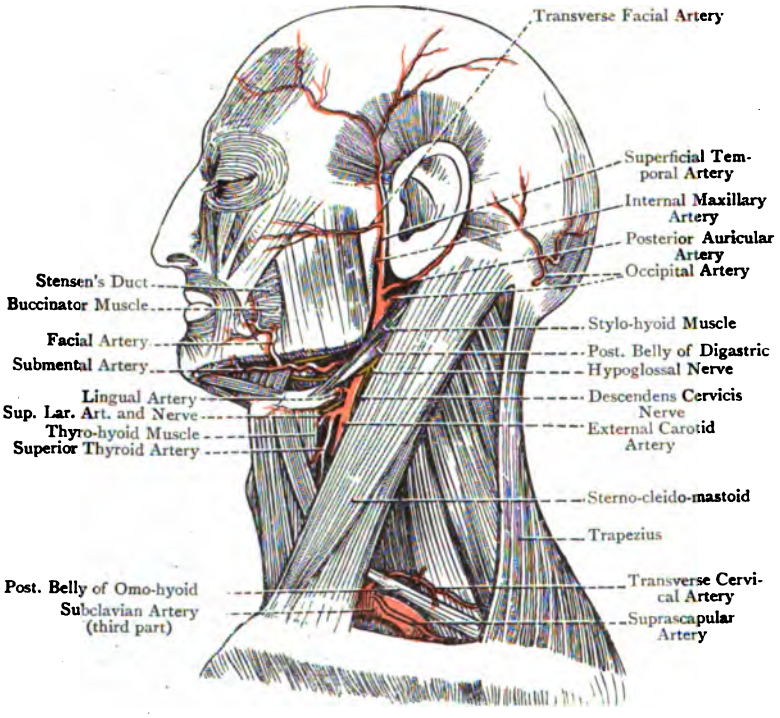

FIG. 430.—THE LEFT SIDE OF THE HEAD AND NECK.

(The Platysma Myoides has been removed).

transverse cervical nerve, and the inframandibular branch of the facial nerve.

The anterior triangle is divided into three triangles by the anterior belly of the omo-hyoid muscle inferiorly, and the two bellies of the digastric muscle superiorly. The subdivisions from below upwards are called muscular, carotid, and digastric or submaxillary.

The **muscular triangle** (inferior carotid) is bounded *anteriorly* by the middle line of the neck; *posteriorly* by the anterior border of the sterno-cleido-mastoid; and *superiorly* by the anterior belly of the omo-hyoid.

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The **carotid triangle** (superior carotid) is bounded *inferiorly* by the anterior belly of the omo-hyoid; *superiorly* by the posterior belly of the digastric and stylo-hyoid; and *posteriorly* by the anterior border of the sterno-cleido-mastoid.

The **digastric** or **submaxillary triangle** is bounded *postero-inferiorly* by the posterior belly of the digastric and stylo-hyoid; *antero-inferiorly* by the anterior belly of the digastric; and *superiorly* by one half of the base of the inferior maxilla, and a line drawn from the angle of that bone to the mastoid process.

Contents of the Triangles—Muscular Triangle.—The area of this triangle is occupied by the sterno-hyoid and sterno-thyroid muscles; hence the name muscular triangle. Under cover of these muscles there are the carotid sheath with its contents, the lateral lobe of the thyroid body, the trachea, and the larynx. The œsophagus lies behind the trachea, with a slight inclination towards the left side at the root of the neck, and the inferior or recurrent laryngeal nerve lies in the groove between the trachea and the œsophagus. The inferior thyroid artery pursues a tortuous course inwards behind the lower part of the carotid sheath, and the gangliated cord of the sympathetic descends behind the sheath.

Carotid Triangle.—This triangle contains the upper part of the common carotid, and the commencements of the external and internal carotid, arteries, all of these being overlapped by the anterior border of the sterno-cleido-mastoid, when the deep fascia which ensheathes that muscle is undisturbed. The common carotid and internal carotid arteries, together with the pneumogastric nerve, are contained within the carotid sheath, and the descendens cervicis nerve lies upon the sheath, or within it, being situated in either case over the common carotid artery. The sterno-cleido-mastoid artery and the superior thyroid vein cross the sheath near the bifurcation of the common carotid artery, and the carotid body lies behind the vessel about the same level. The deep cervical glands lie along the course of the internal jugular vein. The origins of the superior thyroid, lingual, facial, and occipital arteries are contained in this triangle, and the ascending pharyngeal branch of the external carotid lies deeply between that vessel and the internal carotid. The internal jugular vein in this triangle receives the common facial, lingual, and superior thyroid veins. The hypoglossal nerve lies along the lower border of the posterior belly of the digastric muscle, and it here gives off, from behind forwards, the descendens cervicis and thyro-hyoid nerves, the former passing downwards over, or within, the carotid sheath, and the latter passing forwards and downwards at an acute angle with the parent trunk. The internal branch of the superior laryngeal nerve lies deeply behind the bloodvessels, and the external laryngeal branch of that nerve descends internal to them, and passes beneath the depressor muscles of the hyoid bone. The pneumogastric nerve is within the carotid sheath, and the gangliated cord of the sympathetic is behind it. The spinal portion of

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the spinal accessory nerve lies deeply, its course being downwards and backwards beneath the sterno-cleido-mastoid, the deep portion of which it pierces.

Digastric or Submaxillary Triangle.—This triangle is divided into two parts, anterior and posterior, by the stylo-mandibular ligament. The anterior part contains the superficial part of the submaxillary gland, the facial vein being superficial to it, and the facial artery being embedded in its upper and back part. In this triangle the facial artery gives off its inferior or ascending palatine, tonsillar, glandular, and submental branches. The muscles in the floor of the anterior part of the triangle are the mylo-hyoid, and a part of the hyo-glossus. The superficial part of the submaxillary gland rests upon the mylo-hyoid muscle, and conceals the mylo-hyoid nerve and submental artery, which are in direct contact with the muscle. The hypoglossal nerve lies upon that part of the hyo-glossus muscle which appears in the anterior part of the triangle, but it soon disappears beneath the posterior free border of the mylo-hyoid muscle, in company with the deep part of the submaxillary gland and the lingual nerve. The posterior part of the digastric triangle contains a portion of the parotid gland, and under cover of this part is the external carotid artery, which here furnishes its posterior auricular branch.

The anterior jugular vein and the superficial or transverse cervical nerve have been already described (see pp. 1008 and 1018). The inframandibular branch of the facial nerve will be found described on p. 1098.

Lymphatic Glands.—The **submaxillary lymphatic glands** are situated beneath the deep cervical fascia near the base of the inferior maxilla, over the digastric triangle, and are about six in number. They receive their afferent lymphatics from the front part of the tongue, the lateral part of the floor of the mouth, the side of the nose, the upper lip, the outer part of the lower lip, and the submaxillary and sublingual salivary glands. Their efferent lymphatics pass to the superficial, and superior group of the deep cervical, glands.

The **suprahyoid** or **submental glands** are situated beneath the chin in the submental triangle, and are two or three in number. They receive their afferent lymphatics from the tip of the tongue, the front of the floor of the mouth, and the inner part of the lower lip; and their efferent lymphatics pass to the submaxillary lymphatic glands.

The **prelaryngeal glands,** when present, are situated in front of the crico-thyroid membrane, and are one or two in number. They receive their afferent lymphatics from the interior of the larynx, below the rima glottidis, and from the adjacent part of the thyroid body. Their efferent lymphatics pass to the inferior group of deep cervical glands.

The **pretracheal glands** lie in front of the cervical portion of the trachea, from which, as well as from the adjacent part of the

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thyroid body, they receive their afferent lymphatics. Their efferent lymphatics pass to the inferior group of deep cervical glands.

Occasionally a few lymphatic glands are met with along the course of the anterior jugular vein.

Deep Cervical Glands.—These glands lie beneath the sterno-cleido-mastoid muscle, and are about twenty-five in number. They are arranged in two groups, superior and inferior.

The *superior group* lie along the internal jugular vein above the level of the upper border of the thyroid cartilage. They receive their afferent lymphatics from the cranial cavity, the internal maxillary glands, some of the parotid and submaxillary lymphatic glands, the root of the tongue, the upper part of the thyroid body, the larynx, and the lower part of the pharynx. Their efferent lymphatics pass to the glands of the inferior group.

The *inferior group* lie along the lower part of the internal jugular vein, and extend outwards and backwards beneath the sterno-cleido-mastoid, as far as its posterior border, where they give rise to a chain known as the *glandulæ concatenatæ*. The glands of this chain are continuous inferiorly with the supraclavicular glands, and, through these, with the external axillary glands. They receive their afferent lymphatics from the superior group of deep cervical glands, the upper superficial cervical glands, the lower part of the thyroid body, and the cervical portions of the trachea and œsophagus. Their efferent lymphatics unite to form a single vessel, called the **jugular lymphatic trunk,** which opens on the left side into the thoracic duct, and on the right side into the right lymphatic duct.

Infrahyoid Muscles.—These are four in number, on either side, as follows: the omo-hyoid, sterno-hyoid, sterno-thyroid, and thyro-hyoid.

Omo-hyoid.—This muscle consists of two bellies, anterior and posterior, and an intervening tendon. *Origin.*—By means of the **posterior belly** from (1) the upper border of the scapula close to the inner side of the suprascapular notch, and (2) the supra-scapular or transverse ligament, which bridges over the supra-scapular notch.

Insertion.—By means of the **anterior belly** into the outer third of the lower border of the body of the hyoid bone, immediately external to the insertion of the sterno-hyoid muscle.

Nerve-supply.—The anterior belly is supplied by the descendens cervicis nerve, and the posterior belly derives its branches from the ansa cervicis (ansa hypoglossi).

The posterior belly is contained in the posterior triangle of the neck, and separates the occipital from the subclavian or supra-clavicular triangle. Its course is forwards and slightly upwards, and it passes beneath the sterno-cleido-mastoid muscle, where its fibres terminate in the intervening tendon. It is ensheathed by a deep process of the deep cervical fascia, as that fascia crosses the

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posterior triangle, and this process is attached to the back of the inner end of the clavicle and the first rib, which explains the almost horizontal position occupied by the posterior belly.

The anterior belly proceeds from the intervening tendon, and passes upwards and slightly inwards to the body of the hyoid bone. As it emerges from beneath the anterior border of the sterno-cleido-mastoid muscle the anterior belly crosses the carotid sheath on a level with the narrow anterior part of the cricoid cartilage, and in the anterior triangle of the neck it forms the separation between the muscular (inferior carotid) and carotid (superior carotid) triangles.

Sterno-hyoid—*Origin.*—(1) The posterior surface of the manubrium sterni at its upper and outer part; (2) the posterior sterno-clavicular ligament; and, it may be, (3) the posterior surface of the clavicle at its inner end.

Insertion.—The inner two-thirds of the lower border of the body of the hyoid bone, extending from the middle line to the insertion of the anterior belly of the omo-hyoid.

Nerve-supply.—The ansa cervicis (ansa hypoglossi).

The muscle is flat and ribbon-like, and rests upon the sterno-thyroid and thyro-hyoid.

Sterno-thyroid—*Origin.*—(1) The posterior surface of the manubrium sterni at its upper and outer part, below the origin of the sterno-hyoid; and (2) the posterior surface of the first costal cartilage.

Insertion.—The oblique line on the outer surface of the ala of the thyroid cartilage.

Nerve-supply.—The ansa cervicis (ansa hypoglossi).

The muscle is broader, but shorter, than the sterno-hyoid, underneath which it lies. Within the thorax the right muscle lies in front of the innominate artery, and the left in front of the left common carotid artery and left innominate vein. In the neck each muscle rests upon the carotid sheath and the corresponding lateral lobe of the thyroid body.

The sterno-hyoid muscles as they emerge from the thorax are separated by an interval, in which situation the sterno-thyroid muscles lie in close contact. As the muscles ascend, the sterno-hyoids converge, but the sterno-thyroids diverge.

Thyro-hyoid—*Origin.*—The oblique line on the outer surface of the ala of the thyroid cartilage.

Insertion.—(1) The outer half of the lower border of the body of the hyoid bone; and (2) the basal half of the great cornu of that bone.

Nerve-supply.—The thyro-hyoid nerve, which is a special branch of the hypoglossal. The nerve enters the deep surface of the muscle close to its posterior border.

The muscle is quadrilateral. Its superficial surface supports the anterior belly of the omo-hyoid and the sterno-hyoid muscles, and its deep surface is related to the ala of the thyroid cartilage,

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the thyro-hyoid membrane, the internal branch of the superior laryngeal nerve, and the superior laryngeal artery.

The nerves which supply the infrahyoid group of muscles are regarded as being of spinal origin.

Action of the Infrahyoid Muscles—**Omo-hyoid.**—(1) To depress the hyoid bone ; and (2) to render tense the deep cervical fascia in the lower part of the neck.

Sterno-hyoid.—To depress the hyoid bone.

Sterno-thyroid.—To depress the thyroid cartilage.

Thyro-hyoid.—(1) To depress the hyoid bone ; and (2) to elevate the thyroid cartilage, as in the production of high notes, or in deglutition.

Structures in the Median Line of the Neck.—The median line of the neck is divisible into two regions, suprahyoid and infrahyoid.

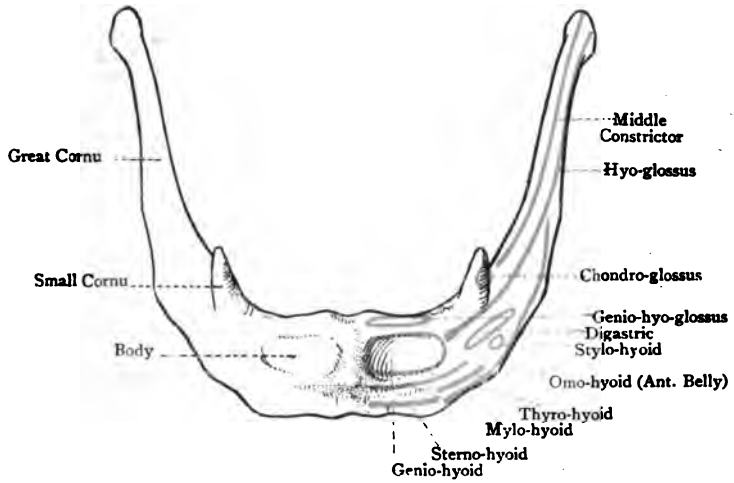

FIG. 431.—THE HYOID BONE, SHOWING ITS MUSCULAR ATTACHMENTS.

Suprahyoid Region.—The innermost fibres of the two platysma myoides muscles decussate at the median line for a short distance below the chin. On either side of the median line, under cover of the platysma myoides, is the anterior belly of the digastric muscle. The anterior bellies of opposite sides are near each other at the chin, but, as they descend with an inclination outwards, they diverge from each other and leave between them a triangular interval, called the **submental triangle.** The base of this triangle is formed by the body of the hyoid bone, and each lateral boundary is constructed by the anterior belly of the digastric, the apex being placed at the chin. The area of the triangle is occupied by the anterior portions of the mylo-hyoid muscles, which meet at the median line in a tendinous raphé, and superficial to these muscles

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there are the suprahyoid or submental glands. Immediately underneath the mesial portions of the mylo-hyoid muscles are the genio-hyoid muscles, these two latter muscles being in very close contact at the median line. Beneath each genio-hyoid muscle is the inferior portion of the genio-hyo-glossus.

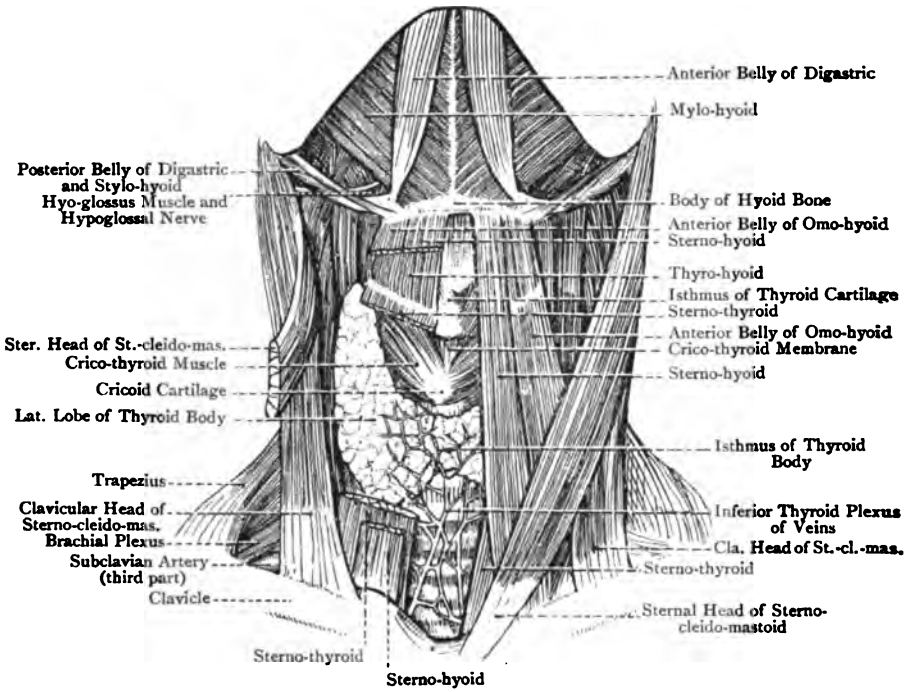

FIG. 432.—DISSECTION OF THE FRONT OF THE NECK.

(The area bounded on either side by the Anterior Belly of the Digastric and below by the body of the Hyoid Bone is the Submental Triangle.)

The relation of structures in the suprahyoid region, from the surface downwards (in a deep direction), is as follows :

1. Platysma myoides.
2. Mylo-hyoid.
3. Genio-hyoid.
4. Genio-hyo-glossus.

Infrahyoid Region.—The region from the hyoid bone downwards to the interclavicular notch on the upper border of the manubrium sterni is of considerable importance in connection with bronchocele or goitre, laryngotomy, and tracheotomy.

The **body of the hyoid bone** is a well-marked structure, along with the **great cornu** on either side of it. Below the hyoid bone there is

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the **thyro-hyoid membrane,** which passes upwards within the lower border of the hyoid bone. The next structure is the **thyroid cartilage,** the upper border of which presents a well-marked median notch, whilst its two alæ form by their union the prominent **isthmus,** or *pomum Adami.*

Succeeding to the thyroid cartilage there is a narrow interval, which is occupied by the **crico-thyroid membrane,** and immediately below this membrane is the narrow anterior part of the **cricoid**

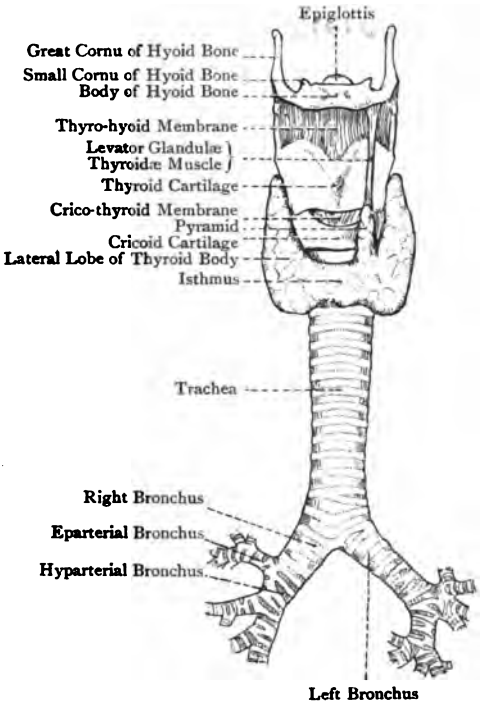

FIG. 433.—THE HYOID BONE, LARYNX, TRACHEA, BRONCHI, AND THYROID BODY (ANTERIOR VIEW).

cartilage. The crico-thyroid membrane is only exposed close to the median line, being elsewhere covered by the two crico-thyroid muscles. The exposed part of the membrane is crossed by the *crico-thyroid arterial arch,* which is situated midway between the thyroid and cricoid cartilages, and lying upon the membrane there may be one or two prelaryngeal lymphatic glands. Laryngotomy may be performed in the crico-thyroid region, and the crico-thyroid arterial arch has to be borne in mind.

Succeeding to the cricoid cartilage is the **trachea,** which, as it descends, inclines backwards, and therefore becomes somewhat

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inaccessible. The **thyroid body** is intimately related to it superiorly. Each *lateral lobe* closely embraces it laterally as low as about the fifth ring, and the *isthmus* lies in front of the second and third rings as a rule, but its position is liable to variation. Crossing the upper border of the isthmus there is one of the branches of the superior thyroid artery, known as the *artery of the isthmus*.

There is nothing of any importance in front of the trachea above the isthmus of the thyroid body. Below the isthmus there is a more or less copious plexus of veins, called the *inferior thyroid plexus*, from which the right and left inferior thyroid veins descend. Occasionally a small artery, called the *arteria thyroidea ima*, ascends directly in front of this part of the trachea, in the median line, to reach the isthmus of the thyroid body. The innominate, and even the right common carotid, artery, and the left innominate vein sometimes encroach upon the front of the trachea towards the root of the neck. In early life the upper part of the **thymus body** covers the front of the trachea. The foregoing structures are covered by the sterno-thyroid and sterno-hyoid muscles in the following manner: the two sterno-thyroid muscles are in contact with each other for a short distance above the manubrium sterni, so as to cover the trachea, but the two sterno-hyoid muscles are here separated by an interval; superiorly the two sterno-thyroid muscles diverge, and the two sterno-hyoid muscles come very nearly together.

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The operation performed upon the trachea is tracheotomy. According as it is performed above or below the isthmus of the thyroid body, it is spoken of as the high operation, or the low operation. In the high operation there is no anatomical obstacle, unless it be a close attachment of the isthmus of the thyroid body to the tracheal rings which it covers. In the low operation the following obstacles are presented: (1) the trachea is here less accessible, because it recedes from the surface; (2) the inferior thyroid plexus of veins might prove troublesome; (3) an arteria thyroidea ima may be present; (4) the innominate and right common carotid arteries, and the left innominate vein may be endangered; and (5) in young children the thymus body would be in the way.

Descendens Cervicis (Descendens Hypoglossi) Nerve.—The descendens cervicis nerve arises from the hypoglossal nerve as the latter hooks round the occipital artery, its fibres being derived from the communicating branch which the hypoglossal receives from the loop between the first and second cervical nerves. The nerve, which is long, passes downwards and slightly forwards, lying upon, or within, the carotid sheath, and in either case directly over the line of the common carotid artery. Before reaching the centre of the neck it furnishes a branch to the anterior belly of the omo-hyoid muscle. Thereafter it is joined by a branch which is formed by the union of the two *rami communicantes cervicis* from the anterior primary divisions of the second and third cervical nerves. These two rami, however, sometimes join it separately. In this manner a loop is formed, which is called the **ansa cervicis**

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(ansa hypoglossi). The convexity of the loop is directed downwards, and from it branches are given off to (1) the sterno-hyoid, (2) the sterno-thyroid, and (3) the posterior belly of the omo-hyoid, muscles.

The fibres of the descendens cervicis nerve are regarded as being of spinal, not hypoglossal, origin.

For the rami communicantes cervicis, see p. 1018.

Thyro-hyoid Nerve.—This nerve, which is composed of spinal fibres, derived from the loop between the first and second cervical nerves, arises from the hypoglossal at the lower border of the

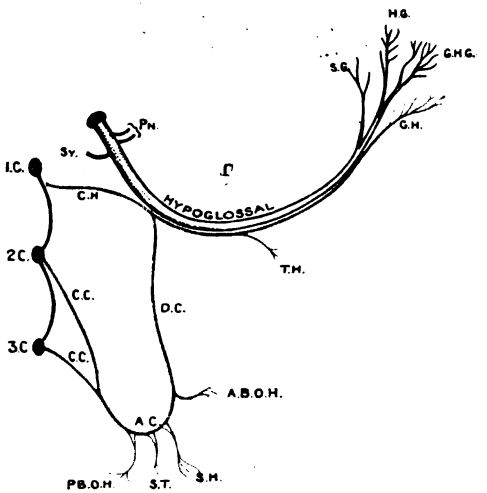

FIG. 434.—SCHEME OF THE HYPOGLOSSAL NERVE, SHOWING ITS CONNECTIONS WITH CERVICAL SPINAL NERVES.

SY. Twig from Sympathetic	S.H. To Sterno-hyoid
PN. Communicating with Pneumogastric	S.T. To Sterno-thyroid
1C, 2C, 3C. First, Second, and Third Cervical	P.B.O.H. To Posterior Belly of Omo-hyoid
C.H. Communicans Hypoglossi	T.H. To Thyro-hyoid
C.C. Communicantes Cervicis	G.H. To Genio-hyoid
D.C. Descendens Cervicis	G.H.G. To Genio-hyo-glossus
A.B.O.H. To Anterior Belly of Omo-hyoid	H.G. To Hyo-glossus
A.C. Ansa Cervicis	S.G. To Stylo-glossus

posterior belly of the digastric. It passes forwards and downwards, forming an acute angle with the parent trunk, and it disappears beneath the posterior border of the thyro-hyoid muscle, immediately after which it enters its deep surface.

Carotid Sheath.—The carotid sheath, as stated in connection with the deep cervical fascia, is derived from the posterior lamina of the sheath of the sterno-cleido-mastoid muscle, and is intimately connected anteriorly with the prevertebral process, and posteriorly with the pretracheal process, of the deep cervical fascia. The interior of the sheath is divided into three compartments—outer,

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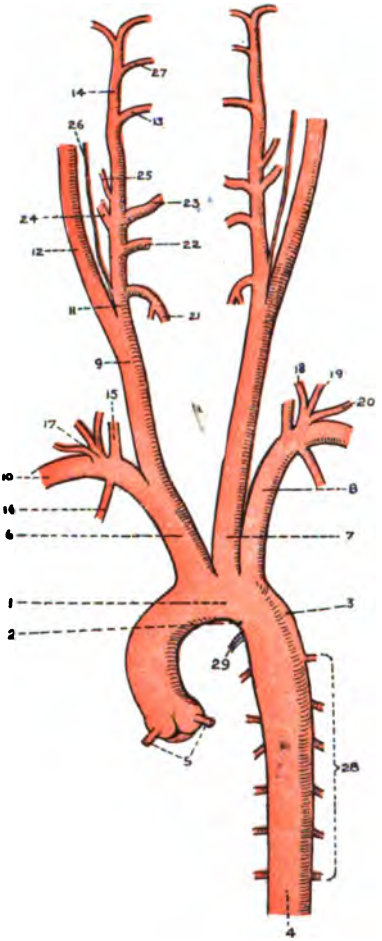

FIG. 449.—THE AORTA IN THE THORAX, AND THE PRINCIPAL ARTERIES OF THE HEAD AND NECK.

1. Arch of the Aorta
2. Aortic Isthmus
3. Aortic Spindle
4. Descending Aorta
5. Coronary Arteries (from Ascending Aorta)
6. Innominate Artery
7. Left Common Carotid
8. Left Subclavian
9. Right Common Carotid
10. Right Subclavian
11. External Carotid
12. Internal Carotid
13. Internal Maxillary
14. Superficial Temporal
15. Vertebral
16. Internal Mammary
17. Thyroid Axis
18. Inferior Thyroid
19. Transverse Cervical
20. Suprascapular
21. Superior Thyroid
22. Lingual
23. Facial
24. Occipital
25. Posterior Auricular
26. Ascending Pharyngeal
27. Transverse Facial
28. Aortic Intercostals
29. Lig. Ductûs Arteriosi

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inner, and posterior, the latter being mesially placed. The outer and inner compartments are separated from each other by a mesial septum, the *inner compartment* containing the common carotid artery and, it may be, the descendens cervicis nerve, and the *outer compartment* the internal jugular vein. The *posterior compartment* is situated within the back part of the septum, and contains the pneumogastric nerve. The descendens cervicis nerve may lie upon the sheath, or within it, and the gangliated cord of the sympathetic descends behind, and in intimate relation with, it.

Common Carotid Arteries.—The *right* common carotid artery arises from the innominate artery behind the upper border of the right sterno-clavicular joint, and the *left* common carotid artery arises from the upper surface of the arch of the aorta, in close proximity to the origin of the innominate artery. The vessel of the right side is therefore entirely cervical, whilst that of the left side is partly thoracic and partly cervical.

The thoracic part of the left common carotid artery has already been described in connection with the thorax (see p. 904).

In the neck the common carotid artery of each side extends from the back of the corresponding sterno-clavicular joint to the level of the upper border of the thyroid cartilage of the larynx, which corresponds to the disc between the bodies of the third and fourth cervical vertebræ. At this level the vessel divides into the external and internal carotid arteries. The place of bifurcation is sometimes opposite the body of the hyoid bone, and, more rarely, on a level with the cricoid cartilage of the larynx. The vessel is about 3¾ inches long, and its course is upwards and outwards in the direction of a line drawn from the sterno-clavicular joint to a point midway between the angle of the inferior maxilla and the mastoid process of the temporal bone. This line, as high as the level of the upper border of the thyroid cartilage, represents the course of the common carotid artery. At the root of the neck the two common carotid arteries are not very far apart, and the trachea lies in the intervening space. As the two vessels ascend they become more divergent, on account of the projection of the lateral lobes of the thyroid body and the thyroid cartilage.

The artery, along with the internal jugular vein and pneumogastric nerve, and, it may be, the descendens cervicis nerve, is contained within the carotid sheath, already described. Opposite the cricoid cartilage it is crossed by the anterior belly of the omo-hyoid muscle. Below this level it lies deeply in the region of the muscular triangle, being under cover of the sterno-hyoid and sterno-thyroid muscles, in addition to the platysma myoides and the anterior border of the sterno-cleido-mastoid. Above this level it is situated in the carotid triangle, being here more superficially placed, its only muscular coverings being the platysma myoides and the anterior border of the sterno-cleido-mastoid.

Relations—*Anterior.*—The skin ; superficial fascia and platysma

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myoides; superficial layer of the deep cervical fascia; anterior border of the sterno-cleido-mastoid; sterno-hyoid; sterno-thyroid; anterior belly of the omo-hyoid; and the anterior wall of the carotid sheath. Three veins cross the artery from without inwards, as follows: the anterior jugular vein crosses it immediately above the clavicle, superficial to the sterno-hyoid and sterno-thyroid muscles; the middle thyroid vein crosses it just below the level of the cricoid

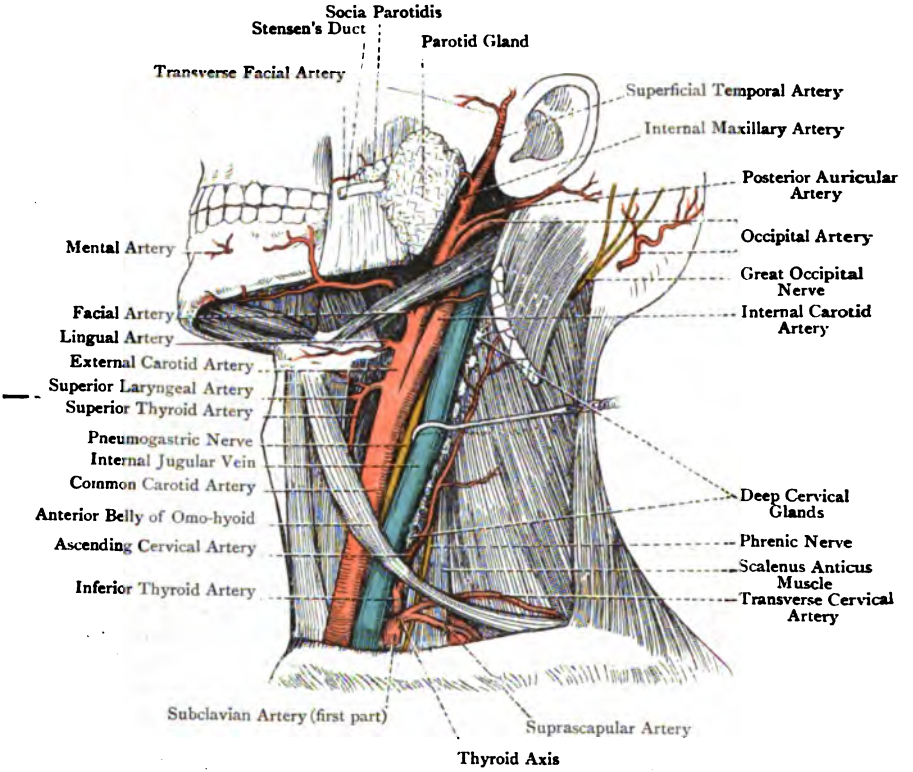

FIG. 436.—DEEP DISSECTION OF THE LEFT SIDE OF THE NECK (AFTER SPALTEHOLZ).

cartilage; and the superior thyroid vein crosses it near its bifurcation. The sterno-cleido-mastoid branch of the superior thyroid artery, which is of small size, passes obliquely downwards and outwards over the carotid sheath in the carotid triangle. The descendens cervicis nerve descends upon, or it may be within, the carotid sheath, lying directly over the artery, and the ansa cervicis (hypoglossi) lies upon the sheath.

Posterior.—The posterior wall of the carotid sheath; the cervical

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transverse processes as high as the level of the fourth; the longus colli, scalenus anticus, and part of the rectus capitis anticus major, muscles; the gangliated cord of the sympathetic, which is intimately related to the posterior wall of the carotid sheath; the recurrent laryngeal nerve; and the inferior thyroid artery, both of which latter structures pass inwards and upwards behind the lower part of the sheath. The carotid body lies behind the vessel close to its bifurcation.

External.—The internal jugular vein and the pneumogastric nerve, the latter lying between the artery and the vein, on a plane posterior to both. At the lower part of the neck, on the right side, the internal jugular vein diverges from the common carotid artery, so as to leave a slight interval in which the right pneumogastric nerve appears as it is about to pass over the first part of the right subclavian artery. On the left side, however, the internal jugular vein is very closely related to the common carotid artery, and more or less overlaps it.

Internal.—From below upwards (1) the trachea and œsophagus, with the recurrent laryngeal nerve and the inferior thyroid artery lying in the intervening groove; (2) the lateral lobe of the thyroid body, upon which the vessel impresses a groove, and by which it may be slightly overlapped; and (3) the larynx and pharynx.

The common carotid artery, as a rule, gives off no branch. The superior thyroid artery, however, may arise from it superiorly, and in some cases the ascending pharyngeal artery.

Surgery—Compression.—The part of the vessel most favourably situated for compression lies in front of the tubercle of the costal process of the sixth cervical vertebra, this tubercle, known as the *carotid tubercle of Chassaignac*, and being on a level with the cricoid cartilage of the larynx.

Ligation.—The part of the vessel most favourably placed for ligation is situated on a level with the cricoid cartilage, just above the point where it is crossed by the anterior belly of the omo-hyoid muscle. The structures to be avoided in the operation are as follows: (1) the descendens cervicis nerve, upon, or it may be within, the sheath; (2) the internal jugular vein and pneumogastric nerve, both of which are within the sheath, and upon the outer side of the artery; and (3) the gangliated cord of the sympathetic, which lies behind, and in close contact with, the sheath. The small sterno-cleido-mastoid artery will probably be cut, as it passes obliquely downwards and outwards over the sheath in the carotid triangle. Ligation of the artery *below* the level of the cricoid cartilage is attended with difficulty, the vessel being here covered by the sterno-hyoid and sterno-thyroid muscles, in addition to the platysma myoides and sterno-cleido-mastoid. On the left side the internal jugular vein would constitute an additional difficulty.

Collateral Circulation after Ligation.—(1) Cross anastomoses take

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place freely between the external and internal carotid arteries of opposite sides. (2) The inferior thyroid artery of the side operated upon anastomoses freely with the superior thyroid of the same side, which is a branch of the external carotid. (3) The deep cervical branch of the superior intercostal, which latter is a branch of the second part of the subclavian artery on the right side, and of the first part on the left side, anastomoses with the ramus cervicalis princeps of the occipital, which is a branch of the external carotid. (4) The vertebral artery undergoes much enlargement.

Carotid Body.—This small body is situated directly behind the common carotid artery close to its bifurcation. It is composed of a few nodules which are invested by connective tissue, and it receives minute twigs from the adjacent part of the common carotid artery. The nodules consist of groups of polyhedral cells, which are permeated by blood-capillaries and sympathetic filaments. The carotid body is similar to the coccygeal gland (body) of Luschka, which is situated in front of the tip of the coccyx.

Development.—The common carotid arteries are developed from the parts of the ventral aortæ which are situated between the third and fourth arterial arches.

Internal Jugular Vein.—The internal jugular vein is the continuation of the intracranial lateral sinus. It commences in the postero-external compartment of the jugular foramen, and terminates behind the inner end of the clavicle by joining the subclavian vein to form the innominate vein. At its commencement it presents a slight dilatation, called the *bulb*. The vein descends vertically, lying at first on the outer side of the internal carotid artery, and subsequently on the outer side of the common carotid artery, the pneumogastric nerve being interposed in each case, and all being enclosed within the carotid sheath. The relations of the vessel for the most part correspond to those of the arteries which it accompanies.

Tributaries.—These are as follows :

Inferior petrosal sinus.	Pharyngeal.
Common facial.	Superior thyroid.
Lingual.	Middle thyroid.

A small vein accompanying the occipital artery may occasionally open into it.

The inferior petrosal sinus leaves the cranial cavity through the antero-internal compartment of the jugular foramen, and opens into the internal jugular vein close to the base of the skull.

Development.—The internal jugular vein is usually regarded as being of later development than the external jugular, and it joins the primitive jugular vein near its lower extremity. According to some authorities it is developed from the primitive jugular vein.

The pneumogastric nerve in the neck will be found described on p. 1148.

External Carotid Artery.—The external carotid artery is one of

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the terminal branches of the common carotid, the other being the internal carotid artery. The two vessels are called external and internal, the one because it is *extracranial* in its distribution, and the other because it is *intracranial*.

The **external carotid artery,** as regards position, is the internal of the two vessels, and it lies anterior to, and nearer the median line than, the internal carotid. It extends from a point on a level with

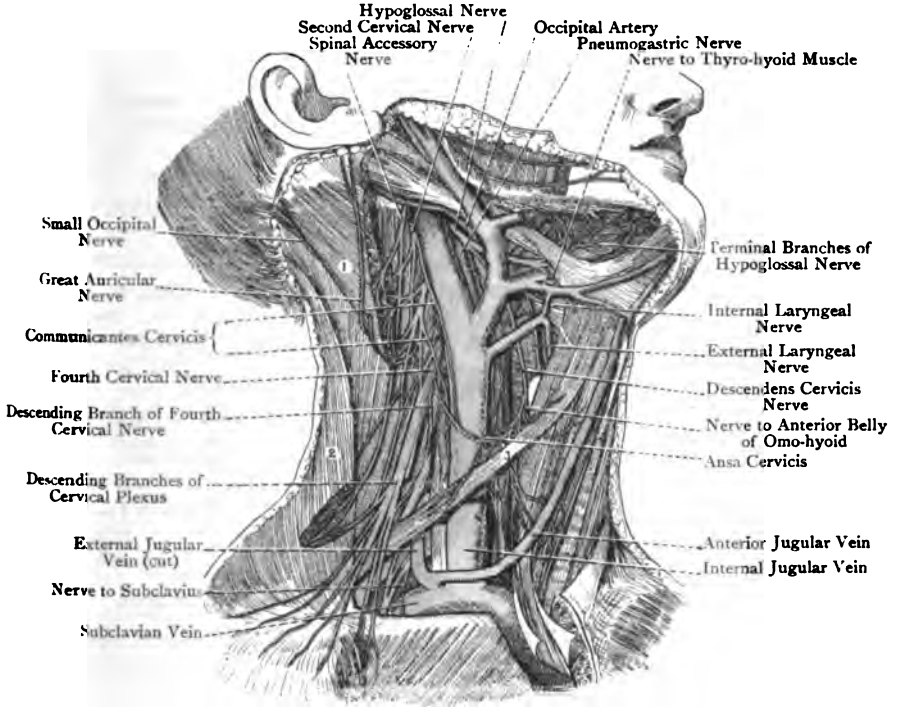

FIG. 437.—DEEP DISSECTION OF THE RIGHT SIDE OF THE NECK (AFTER HIRSCHFELD AND LEVEILLÉ).

1, Upper Part of Sterno-cleido-mastoid; 2, Trapezius; 3, Tendon of Omo-hyoid.

the upper border of the thyroid cartilage to a point immediately behind the neck of the inferior maxilla, where it divides, in the substance of the parotid gland, into the superficial temporal and internal maxillary arteries. It is about 2½ inches in length, and its direction is upwards and slightly backwards. At first the artery lies in the carotid triangle, and is comparatively superficial. As it leaves this triangle it is more deeply placed, being crossed by the posterior belly of the digastric and stylo-hyoid muscles, and the hypoglossal nerve. Thereafter the vessel is em-

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bedded in the substance of the parotid gland, where it is crossed from behind forwards by the facial nerve.

Relations—*Anterior.*—The skin; superficial fascia; platysma myoides; deep fascia; anterior border of the sterno-cleido-mastoid; the lingual and common facial veins; the hypoglossal nerve (all the foregoing being anterior relations, whilst the artery lies in the superior carotid triangle); the posterior belly of the digastric and stylo-hyoid muscles; the greater part of the parotid gland; the temporo-maxillary vein; and the facial nerve. *Posterior.*—The

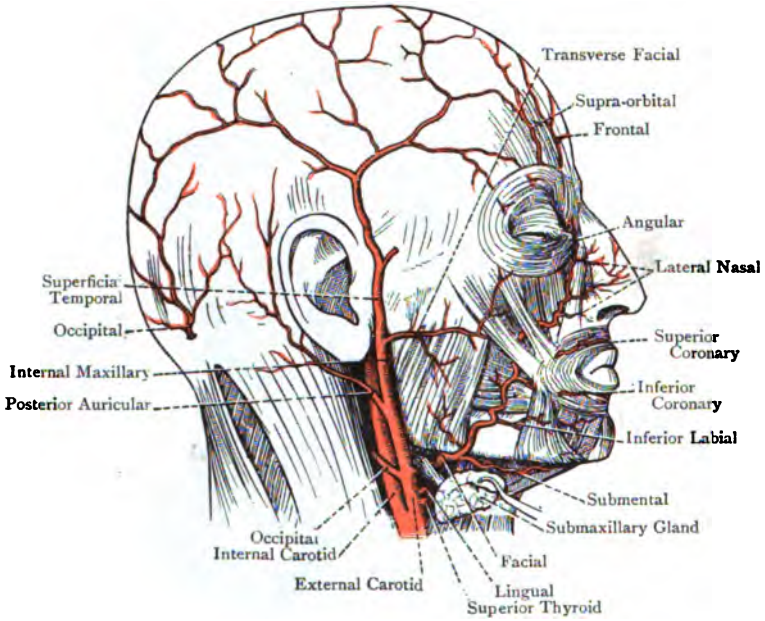

FIG. 438.—THE ARTERIES OF THE RIGHT SIDE OF THE HEAD (AFTER L. TESTUT'S 'ANATOMIE HUMAINE').

chief posterior relations are as follows: (1) the stylo-pharyngeus muscle, glosso-pharyngeal nerve, and styloid process of the temporal bone, all of which intervene between the vessel and the internal carotid (the latter now lying behind the external carotid); and (2) a small portion of the parotid gland. *External.*—The internal carotid artery for a short distance. *Internal.*—The pharynx and hyoid bone; the superior laryngeal nerve; a portion of the parotid gland; and the posterior border of the ramus of the inferior maxilla.

The external carotid artery has no vein in the sense of a companion vessel, but the temporo-maxillary vein descends in front of

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it, in the parotid gland, to near the angle of the inferior maxilla, beyond which point the artery has no vein.

The course of the vessel may be indicated by a line drawn from the side of the cricoid cartilage of the larynx to the tragus of the auricle.

Development.—The external carotid artery is the persistent part of the ventral aorta above the level of the third arterial arch.

Branches.—These are arranged in four sets, anterior, posterior, ascending, and terminal, and are as follows :

Anterior.	Posterior.	Ascending.	Terminal.
Superior thyroid.	Occipital.	Ascending	Superficial temporal.
Lingual.	Posterior auricular.	pharyngeal.	Internal maxillary.
Facial.			

Superior Thyroid Artery.—This vessel arises in the carotid triangle from the front part of the external carotid close to its commencement. It takes an arched course forwards and downwards, passing under cover of the depressor muscles of the hyoid bone. On reaching the apex of the lateral lobe of the thyroid body it breaks up into its terminal branches, which enter the lobe on its superficial aspect, and anastomose freely, within it, with branches of the inferior thyroid artery, and, in the isthmus, with its fellow of the opposite side.

Branches.—These are as follows :

Infrahyoid.	Crico-thyroid.
Sterno-cleido-mastoid.	Glandular.
Superior laryngeal.	Muscular.

The *infrahyoid artery* passes inwards on the thyro-hyoid membrane, beneath the thyro-hyoid muscle, and close to the lower border of the hyoid bone. It anastomoses at the middle line with its fellow of the opposite side, and with the suprahyoid branch of the lingual artery of the same side. The *sterno-cleido-mastoid artery* passes obliquely downwards and outwards, over the upper part of the carotid sheath, to enter the deep surface of the muscle from which it takes its name. It is liable to be cut in ligation of the common carotid artery. The *superior laryngeal artery* accompanies the internal laryngeal nerve, and passing beneath the outer border of the thyro-hyoid muscle, it pierces the thyro-hyoid membrane, to be distributed to the interior of the larynx. The *crico-thyroid artery* passes transversely inwards upon the crico-thyroid membrane, and anastomoses with its fellow of the opposite side to form the *crico-thyroid arch*. This arch is situated midway between the cricoid and thyroid cartilages, but, notwithstanding this position, it may be in danger in the operation of laryngotomy. The *glandular branches* are distributed to the lateral lobe of the thyroid body. They anastomose freely with

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branches of the inferior thyroid of the same side, and with branches of its fellow of the opposite side. One very constant branch, known as the *artery of the isthmus*, courses along the upper border of the isthmus, and anastomoses with its fellow of the opposite side. The *muscular branches* are distributed to the depressor muscles of the hyoid bone.

The **superior thyroid vein** issues from the upper part of the lateral lobe of the thyroid body, and crosses in front of the common carotid artery, near its bifurcation, to open into the internal jugular vein. Its tributaries for the most part correspond to the branches of the artery, amongst these being the crico-thyroid and superior laryngeal veins.

Lingual Artery.—The lingual artery arises from the front part of the external carotid, a little above the origin of the superior thyroid, and opposite the great cornu of the hyoid bone. From its com-

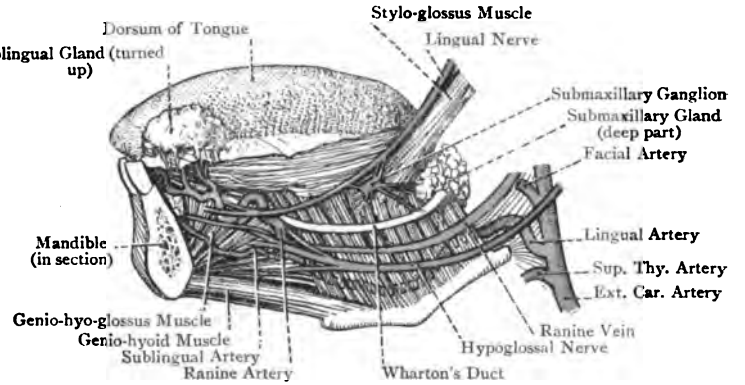

FIG. 439.—DEEP DISSECTION OF THE LEFT SUBMAXILLARY REGION.

plicated course it is convenient to divide the artery into three parts.

First Part.—The first part of the vessel ascends for a little, and then, bending sharply, descends to the upper border of the hyoid bone, passing beneath the posterior belly of the digastric and stylo-hyoid muscles. So far the vessel lies in the carotid triangle and the bend which it describes is crossed by the hypoglossal nerve. It is for the most part comparatively superficial.

Second Part.—The second part passes horizontally forwards along the upper border of the hyoid bone beneath the hyo-glossus muscle, the hypoglossal nerve and ranine vein being superficial to that muscle. At the anterior border of the hyo-glossus it enters upon the third part of its course. The second part lies deeply in **Lesser's triangle,** the boundaries of which are as follows : the *base,* which is directed upwards, is formed by a portion of the hypo-

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glossal nerve; the *two sides* are formed by the tendon of the digastric, which is here disposed in the form of a **V**; and the *floor* is formed by the hyo-glossus muscle. The artery lies under cover of that muscle, and rests upon the middle constrictor of the pharynx.

Third Part.—Near the anterior border of the hyo-glossus muscle the lingual artery describes another sharp bend in an upward direction, and ascends almost vertically to the under surface of the tongue, resting upon the genio-hyo-glossus, and being under cover of the anterior border of the hyo-glossus. Having reached the tongue, the artery passes forwards on its under surface in a tortuous manner, under the name of the ranine artery.

Branches.—These are as follows:

1. Suprahyoid.
2. Dorsalis linguæ.
3. Sublingual.
4. Ranine.

The *suprahyoid artery* arises from the lingual at the posterior border of the hyo-glossus, and passes inwards along the upper border of the hyoid bone to supply the adjacent structures. At the median line it anastomoses with its fellow of the opposite side, and with the infrahyoid branch of the superior thyroid of the same side.

The *dorsalis linguæ artery* arises under cover of the hyo-glossus muscle, which it pierces, and so reaches the posterior third of the dorsum of the tongue. It is distributed to the mucous membrane and substance of the tongue, the tonsil, and the soft palate, and it anastomoses with its fellow of the opposite side.

The *sublingual artery* arises close to the anterior border of the hyo-glossus muscle. It supplies the sublingual gland, the adjacent muscles, and the mucous membrane of the floor of the mouth. One of the lateral branches anastomoses at the median line with a corresponding branch of the opposite artery, and another of them is known as the *artery of the frenum linguæ*.

The *ranine artery* is the terminal part of the lingual. It passes forwards on the under surface of the tongue, lying immediately external to the insertion of the genio-hyo-glossus, between it and the inferior lingualis. It is more or less embedded in the substance of the tongue, and its course is tortuous in adaptation to the mobility of the organ to which it is so intimately related. Towards the tip of the tongue the vessel is very superficially placed, lying close by the side of the frenum linguæ, and it anastomoses with its fellow of the opposite side near the tip. Elsewhere the cross anastomoses are unimportant. The ranine artery furnishes branches freely to the substance of the tongue. Its close relation to the frenum linguæ is to be carefully noted in connection with the operation for relief of tongue-tied children.

The **lingual veins** are as follows: (1) the *ranine vein*, which is of large size, commences under the tip of the tongue, and passes

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backwards, in company with the hypoglossal nerve, over the hyo-glossus muscle, receiving tributaries from the surrounding structures; (2) two *venæ comites* accompanying the lingual artery; and (3) the *dorsal lingual veins*, which originate in a plexus beneath the mucous membrane over the posterior third of the organ. These three sets of veins may join into a common trunk, called the **lingual vein**, which opens into the internal jugular vein, or they may terminate independently in that vein.

Facial Artery.—The facial artery arises from the front part of the external carotid in the carotid triangle, immediately above the lingual artery, or sometimes in common with that vessel. It passes upwards and forwards, beneath the hypoglossal nerve and the posterior belly of the digastric and stylo-hyoid muscles, into the submaxillary triangle. Thereafter it becomes embedded in a groove on the upper and back part of the submaxillary gland, its course in this situation being horizontally forwards. Having emerged from this groove, it describes a sharp bend and mounts upwards over the base of the inferior maxilla, in front of the masseter muscle. The vessel then enters upon the facial part of its course, for a description of which see p. 1102.

Branches.—Four branches arise from the cervical part of the facial artery, as follows:

1. Inferior palatine.
2. Tonsillar.
3. Glandular.
4. Submental.

The *inferior palatine artery* passes upwards between the stylo-glossus and stylo-pharyngeus muscles, and then over the upper border of the superior constrictor of the pharynx, along with the levator palati muscle. It is distributed to the soft palate, tonsil, and Eustachian tube. The *tonsillar artery* passes upwards between the stylo-glossus and internal pterygoid muscles, and, after piercing the superior constrictor muscle, it is distributed to the tonsil and the posterior part of the side of the tongue. The *glandular branches* are distributed to the submaxillary gland. The *submental artery* arises from the facial as it is about to mount over the base of the inferior maxilla, and it passes forwards upon the mylo-hyoid muscle. It gives branches to the submaxillary gland and mylo-hyoid muscle, some of the branches piercing that muscle to reach the sublingual gland and anastomose with the sublingual artery. Near the symphysis it ascends over the base of the inferior maxilla, and supplies the muscles of the lower lip and the integument of the chin. The terminal part of the vessel anastomoses with the mental and inferior labial arteries, and with its fellow of the opposite side.

The cervical part of the **facial vein** passes downwards and backwards superficial to the submaxillary gland. Having received tributaries corresponding to the branches of the cervical part of the artery, it unites with the anterior division of the temporo-maxillary

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vein to form the **common facial vein,** which opens into the internal jugular opposite the body of the hyoid bone.

Occipital Artery.—The occipital artery arises from the posterior aspect of the external carotid opposite the facial artery. It passes at first upwards and slightly backwards beneath the posterior belly of the digastric and stylo-hyoid muscles, and the hypoglossal nerve, having hooked round it, passes forwards over it. Having reached the level of the interval between the transverse process of the atlas and the mastoid process, the artery changes its course, and passes backwards to occupy the occipital groove on the inner aspect of the mastoid process. In this backward course it crosses the internal carotid artery, internal jugular vein, and pneumogastric, spinal accessory, and hypoglossal nerves. As it lies in the occipital groove the vessel is very deeply placed, being covered by the following structures : (1) the origin of the posterior belly of the digastric ; (2) the trachelo-mastoid ; (3) the splenius capitis ; and (4) the sterno-cleido-mastoid. After escaping from beneath the splenius capitis, the vessel takes an upward course over the complexus to the occipital region, where it ramifies in a tortuous manner, along with the branches of the great occipital nerve.

Branches.—These are as follows : muscular ; meningeal ; mastoid ; ramus princeps cervicis ; and terminal.

The *muscular branches* are distributed to the adjacent muscles. One of them crosses the hypoglossal nerve and enters the deep surface of the sterno-cleido-mastoid muscle, in company with the spinal portion of the spinal accessory nerve. The *meningeal branch* accompanies the internal jugular vein, and enters the cranial cavity through the jugular foramen to supply the dura mater of the posterior fossa. The *mastoid branch* passes through the arterial fissure in the mastoid process, and supplies the adjacent dura mater. The ramus princeps cervicis and the terminal branches have been already described (see p. 987).

The occipital veins will be found described on p. 988.

Posterior Auricular Artery.—This vessel arises from the posterior aspect of the external carotid a little above the origin of the occipital artery, and above the posterior belly of the digastric. It passes upwards and slightly backwards under cover of the lower part of the parotid gland, and over the styloid process of the temporal bone, being crossed by the facial nerve. Having reached the groove between the back of the auricle and the mastoid process, where it meets the posterior auricular nerve, it divides into two branches, auricular and mastoid.

Branches.—These are as follows : muscular ; glandular ; stylo-mastoid ; auricular ; and mastoid.

The *muscular branches* supply the adjacent muscles. The *glandular branches* are distributed to the lower part of the parotid gland. The *stylo-mastoid artery* enters the aqueduct of Fallopius through the stylo-mastoid foramen. It is distributed to the tympanic cavity and the mastoid cells, and anastomoses with

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the tympanic branch of the first part of the internal maxillary artery. With this latter branch it forms a ring at the circumference of the membrana tympani on its inner aspect. Within the aqueduct of Fallopius the stylo-mastoid artery anastomoses with the petrosal branch of the middle meningeal artery, which branch enters the aqueduct through the hiatus Fallopii. The *auricular branch* passes upwards beneath the retrahens auriculam muscle, and furnishes branches to the inner aspect of the auricle, some of which reach the outer surface by piercing the cartilage and by turning round its margin. The auricular branch anastomoses with the posterior division of the superficial temporal artery. The *mastoid branch* passes backwards over the mastoid process to the occipital region, and anastomoses with the occipital artery.

The **posterior auricular vein,** of fairly large size, unites with the posterior division of the temporo-maxillary vein near the angle of the inferior maxilla, and by this union the external jugular vein is formed.

Ascending Pharyngeal Artery.—This long, slender vessel arises from the deep surface of the external carotid near its commencement. It passes vertically upwards towards the base of the skull, lying very deeply upon the rectus capitis anticus major muscle, and between the internal carotid artery and the pharynx.

Branches.—These are as follows :

1. Pharyngeal.
2. Palatine.
3. Prevertebral.
4. Tympanic.
5. Meningeal.

The *pharyngeal branches* are distributed to the pharynx. The *palatine branch* passes over the superior constrictor muscle of the pharynx, and is distributed to the soft palate, Eustachian tube, and tonsil. The *prevertebral branches* supply the prevertebral muscles. The *tympanic branch* passes with the tympanic branch of the glosso-pharyngeal nerve through the tympanic canaliculus in the petrous part of the temporal bone, and so reaches the tympanum, to the inner wall of which it is distributed. The *meningeal arteries* are the terminal branches of the ascending pharyngeal, and are three in number. One passes through the foramen lacerum medium, a second through the jugular foramen, and a third through the anterior condylar foramen, to be distributed to the dura mater in the vicinity of these foramina.

No specially-named vein accompanies the ascending pharyngeal artery.

For the superficial temporal and internal maxillary branches of the external carotid artery, see pp. 995 and 1124.

The internal carotid artery will be found described on p. 1144.

Thyroid Body.—The thyroid body is situated on either side of the upper part of the trachea and the larynx, and a small portion of

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it lies in front of the upper part of the trachea. Its size is subject to much variation; its weight is rather more than 1 ounce; and it is larger in the female than in the male. It consists of two lateral lobes and an isthmus.

Each **lateral lobe** is conical, the rounded base being directed downwards, and it measures about 2 inches in length. It extends from the inferior cornu and adjacent portion of the ala of the thyroid cartilage to about the level of the fifth ring of the trachea. Its *superficial surface*, which looks forwards and outwards, is somewhat convex, and is covered by the sterno-thyroid, sterno-hyoid, and anterior belly of the omo-hyoid muscles. It is also overlapped by the anterior border of the sterno-cleido-mastoid. Its *deep surface* is concave in adaptation to the trachea and larynx. The *anterior border* is thin, and towards its lower part is connected with that of the opposite lateral lobe by means of the isthmus. The *posterior border* is thick, and is in contact with the pharynx and œsophagus. The lateral lobe slightly overlaps the common carotid artery, enclosed in the carotid sheath, and is frequently grooved by that vessel. Inferiorly it overlaps the recurrent laryngeal nerve and inferior thyroid artery. The apex of the lateral lobe rests upon the inferior constrictor muscle of the pharynx, and the superior thyroid artery enters it superficially.

The **isthmus** is inconstant as regards size and position. Its depth ranges from ¼ to 1 inch, and its breadth is about ½ inch. It connects the lower parts of the anterior borders of the lateral lobes, but does not reach quite so low as their bases. It lies in front of the trachea, usually upon the second and third rings, sometimes upon the upper three rings, or it may be the second, third, and fourth rings. It fits closely to the rings upon which it rests. Along its upper border there is a branch of the superior thyroid artery, known as the *artery of the isthmus*, which anastomoses with its fellow of the opposite side. From its lower border several veins issue, which take part in the inferior thyroid plexus of veins in front of the trachea.

In some cases an additional lobe is present, called the **pyramidal, or middle, lobe.** It takes the form of a long pyramid which is attached by its base to the upper border of the isthmus, usually at its junction with the left lateral lobe. Its apex is attached to the body of the hyoid bone by a fibrous band, which sometimes contains muscular fibres, known as the *levator glandulæ thyroideæ muscle.*

The thyroid body is invested by a fibrous sheath which is derived from the pretracheal lamina of the deep cervical fascia.

When a portion or portions of the pyramidal lobe, or of a lateral lobe, become detached, the isolated masses are known as **accessory thyroids.**

Blood-supply—Arteries.—The thyroid body is characterized by great vascularity. The arteries on either side are (1) the superior thyroid, which is a branch of the external carotid, and (2) the

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inferior thyroid, which is a branch of the thyroid axis of the first part of the subclavian. Occasionally there is a third thyroid artery, called the *arteria thyroidea ima*, which is derived from the innominate artery, or from the arch of the aorta, and is distributed to the isthmus, its position being in front of the trachea at the median line, or close to it.

The **veins** are three in number on either side, namely, superior,

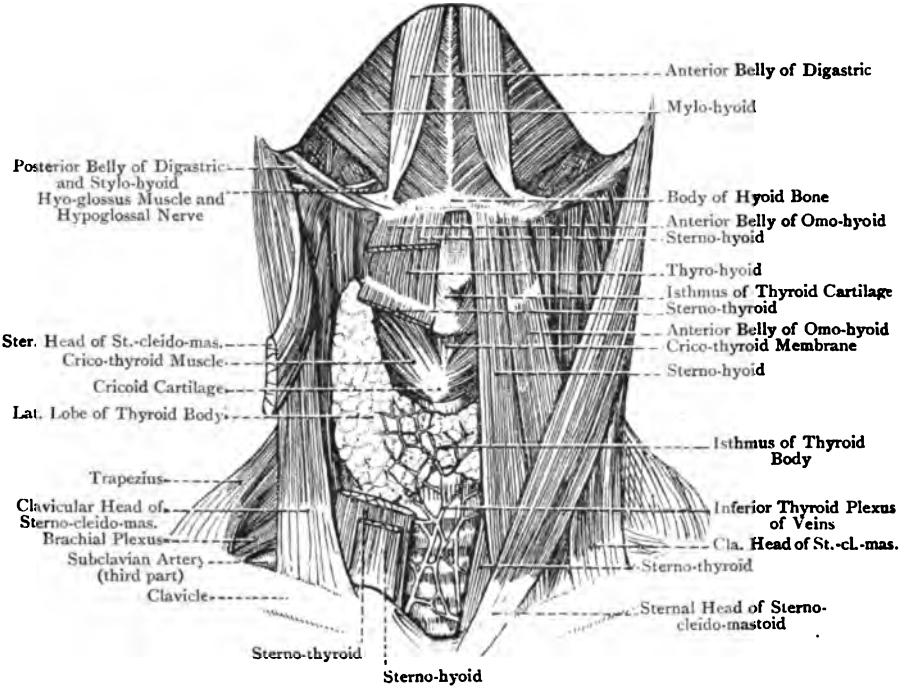

FIG. 440.—DISSECTION OF THE FRONT OF THE NECK.

(The area bounded on either side by the Anterior Belly of the Digastric and below by the body of the Hyoid Bone is the Submental Triangle.)

middle, and inferior. The **superior** and **middle thyroid veins** open into the internal jugular. The **inferior thyroid veins,** right and left, issue from a plexus of veins in front of the trachea below the isthmus. The *left* vein opens into the left innominate vein, whilst the right has a variable mode of termination. It may open into the left innominate vein, or into the angle of junction of the right and left innominate veins, or into the lower part of the right innominate vein.

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Nerves.—These are derived from the sympathetic plexuses which accompany the superior and inferior thyroid arteries.

Structure. — The thyroid body has an external capsule of dense connective tissue which sends trabeculæ into the interior, thereby dividing it into irregular lobules. These **lobules** are composed of groups of **closed vesicles,** which are connected together by areolar tissue. The vesicles are oval or spherical, and each is lined with a single layer of columnar, or cubical, epithelium. They contain a yellowish, viscid, albuminous fluid called *colloid,* and are surrounded by networks of capillary bloodvessels.

Development.—The thyroid body is developed from three tubular diverticula —median and two lateral. The **median diverticulum,** which is known as the *ductus thyro-glossus,* is derived from the pharyngeal hypoblast opposite the second visceral clefts, between the tuberculum impar (which gives rise to the anterior two-thirds of the tongue), and the root or pharyngeal part of the tongue. The upper part of this diverticulum soon loses its connection with the pharyngeal hypoblast, and its upper extremity persists as the *foramen cæcum* of the tongue. The lower part gives rise to the **isthmus** of the thyroid body, and the intervening portion disappears. The part of this diverticulum, however, which is adjacent to the isthmus frequently undergoes development, and so gives rise to the **pyramidal,** or **middle, lobe.**

Each **lateral diverticulum** is derived from the fourth visceral cleft of the corresponding side, and it gives rise to the lateral lobe, which joins the isthmus on either side.

The three diverticula become transformed into cylinders of cells, which branch and anastomose with one another. The cylinders then become hollow, and are broken up into the vesicles which contain the colloid.

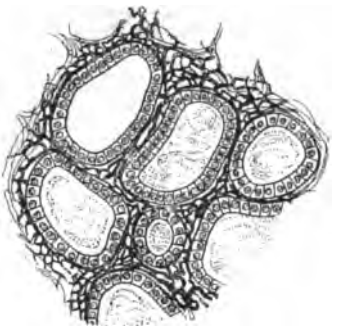

FIG. 441. — SECTION OF THE THYROID BODY, SHOWING THE VESICLES AND THEIR EPITHELIAL LINING.

(The Colloid is indicated.)

Parathyroids.—These are two in number on either side. One is related to the posterior border of the lateral lobe, and the other to its mesial border. Each is about ¼ inch in diameter, and consists of a collection of epithelial cells pervaded by bloodvessels. They are probably developed in connection with the thymus body.

The Trachea and Œsophagus.

Trachea.—The trachea extends from the cricoid cartilage of the larynx to about the level of the disc between the bodies of the fourth and fifth thoracic vertebræ, where it divides into the two bronchi, right and left. Its average length is about 4½ inches, and its width about 1 inch. Anteriorly and laterally it is cylindrical and firm, but posteriorly it is flattened and membranous, so that it does not press upon the œsophagus, over which it lies. It occupies a mesial position, and its direction is downwards with an inclination backwards. It is divisible into two parts, cervical and thoracic.

For the trachea in the thorax, see p. 945.

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The **cervical part of the trachea** extends from the cricoid cartilage to the level of the upper border of the manubrium sterni, and it measures about 2½ inches in length. It is freely movable, and is surrounded by areolar tissue, which contains many elastic fibres, and is somewhat loosely arranged.

Relations—*Anterior.*—The isthmus of the thyroid body lies directly upon the second and third rings as a rule, the first ring usually lying exposed between its upper border and the cricoid

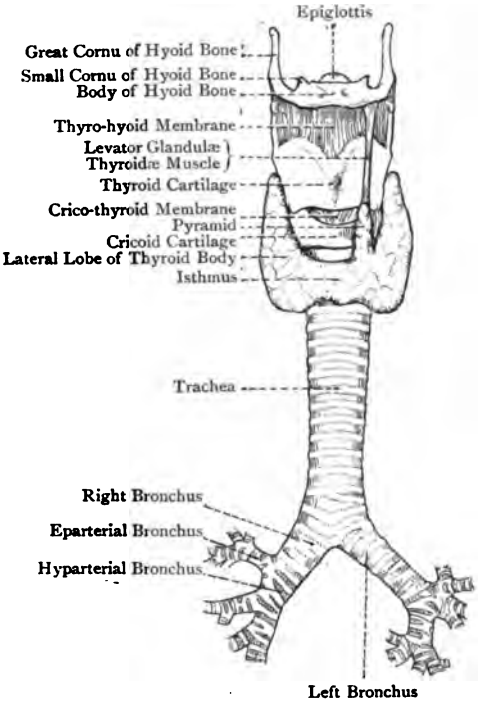

FIG. 442.—THE HYOID BONE, LARYNX, TRACHEA, BRONCHI, AND THYROID BODY (ANTERIOR VIEW).

cartilage. Superficial to the first ring, on the left of the median line, there may be the lower part of the pyramidal, or middle, lobe of the thyroid body. Below the isthmus is the inferior thyoid plexus of veins, from which the right and left inferior thyroid veins pass downwards, one on either side of the median line. The arteria thyroidea ima may ascend to the isthmus of the thyroid body, lying in front of the trachea at the median line, or slightly to the right of it. The anterior jugular veins, right and left, are anterior to it, and just above the manubrium sterni it is

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crossed by the communicating branch which passes between these two veins. In children under two years of age the cervical portion of the thymus body forms an important anterior relation. Close to the upper border of the manubrium sterni the innominate artery may encroach slightly upon it. The pretracheal lamina of the deep cervical fascia forms an anterior relation, as well as the superficial layer of that fascia, which layer is here arranged in two divisions enclosing the space of Burns and the anterior jugular veins, along with one or two lymphatic glands. The sterno-hyoid and sterno-

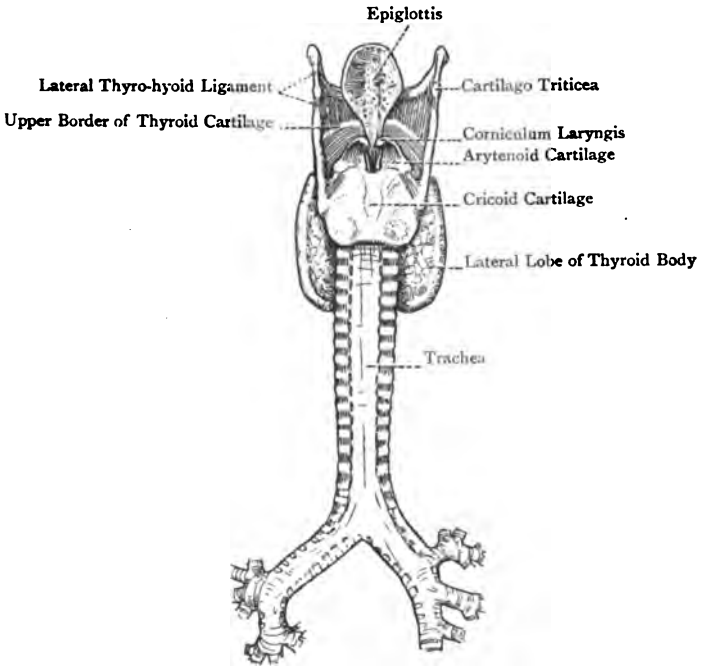

FIG. 443.—THE EPIGLOTTIS, LARYNX, TRACHEA, BRONCHI, AND THYROID BODY (POSTERIOR VIEW).

thyroid muscles cover it in the following manner: the sterno-hyoid muscles are separated by an interval below, but they come nearly into contact above; and the sterno-thyroid muscles are in contact below, but diverge above. Between the muscles of opposite sides there is a very narrow interval, along which the trachea is free from muscular covering, the pretracheal fascia being here of some strength.

Lateral.—The trachea is closely embraced on either side by the lateral lobe of the thyroid body as low as about the level of the fifth

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ring, and external to this is the carotid sheath with its contents, the common carotid artery being nearest the lateral lobe.

Posterior.—The trachea rests upon the œsophagus, which projects a little to its left side towards the root of the neck. Between the two there is a groove, in which the recurrent laryngeal nerve and inferior laryngeal artery ascend.

For a reference to the high and low operations of tracheotomy, see p. 1032.

Blood-supply.—The **arteries** of the cervical part of the trachea are

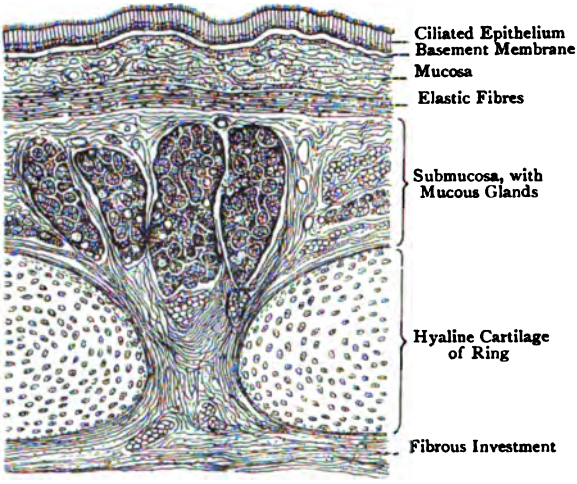

FIG. 444.—LONGITUDINAL SECTION OF THE TRACHEA.

derived from the inferior thyroid of each side, which is a branch of the thyroid axis.

The **veins** terminate in the inferior thyroid plexus and inferior thyroid veins.

The **lymphatics** pass to the lower group of deep cervical glands.

Nerve-supply.—The nerves are derived from the pneumogastric, recurrent laryngeal, and sympathetic.

Structure.—The trachea is composed of about twenty so-called rings of hyaline cartilage, which are incomplete posteriorly. They serve to keep the tube permanently open for the transmission of air, and are embedded in fibrous tissue, which also connects together their contiguous borders. They are shaped thus—C, and each forms rather more than two-thirds of a circle, being flat externally, and convex internally. The deficient portions of the rings are, as stated, placed posteriorly, and here each ring ends in two round extremities. The intervals between these extremities are bridged over by fibrous tissue, continuous with that which connects the borders of the rings and in which they are embedded. In some cases a ring may terminate in a bifurcated extremity, or it may join one of the adjacent rings. The lowest ring is deep, and its lower border projects backwards so as to form a ridge between the openings of the two bronchi.

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In the posterior wall of the trachea, within the **fibrous layer,** there is a continuous layer of **unstriped muscular tissue.** the fibres of which extend transversely between the ends of the rings to which they are attached. In the intervals between the extremities of the rings they are attached to the fibrous coat. These fibres serve to approximate the ends of the rings, and so diminish the calibre of the tube.

The **submucous coat** consists of loosely-arranged areolar tissue, and contains the larger bloodvessels and nerves, together with the mucous glands.

The **mucous coat** consists of areolar and elastic tissues, and a large amount of lymphoid or adenoid tissue. It contains the ramifications of the arteries and nerves, as well as the lymphatics. Superficial to the mucosa there is a well-marked basement membrane which supports the epithelium. The deep portion of the mucosa consists principally of elastic fibres. On the posterior wall these elastic fibres are very numerous, and are arranged in longitudinal bundles which give rise to elevations of the mucosa.

The **epithelium** is of the stratified columnar ciliated variety.

The wall of the trachea contains many **mucous glands.** Some of these are situated in the submucous coat. Others, which are of large size, are situated on the posterior wall, where they are very superficial, many of them, like small grains, lying superficial to the fibrous layer, where they are quite visible. Others are contained within the fibrous layer. The ducts of these glands have to pass through (1) the muscular layer, (2) the elastic layer (part of the mucosa), and (3) the mucosa, upon the surface of which they open by apparent orifices.

Development.—The trachea is developed from the lower part of a median diverticulum from the ventral aspect of the fore-gut superiorly, the upper part of this diverticulum giving rise to the larynx.

Œsophagus.—The œsophagus is that part of the alimentary canal which extends from the pharynx to the stomach. In the neck it commences on a level with the lower border of the cricoid cartilage, and terminates on a level with the upper border of the manubrium sterni. It is compressed from before backwards, and lies between the trachea and the vertebral column covered by the longus colli muscles. At first it occupies the median line, but as it descends it inclines slightly to the left side, so as to be partially visible on the left side of the trachea.

Relations—*Anterior.*—The trachea; the posterior parts of the lateral lobes of the thyroid body; the recurrent laryngeal nerves; and the inferior thyroid arteries. *Posterior.*—The vertebral column and the longus colli muscles, covered by the prevertebral fascia. *Lateral.*—On either side there is the carotid sheath with its contents. The right and left recurrent laryngeal nerves are intimately related to the œsophagus, and ascend on each side in the groove between it and the trachea.

The cervical part of the œsophagus receives its blood-supply from the inferior thyroid arteries, right and left, each of which accompanies the corresponding recurrent laryngeal nerve.

For a description of the œsophagus in the thorax, including its structure and development, see p. 947.

Suprahyoid Region—Muscles—Digastric.—The digastric muscle consists of two bellies, posterior and anterior. *Origin.*—The **posterior belly** arises from the digastric groove on the inner aspect of the mastoid part of the temporal bone; and the **anterior belly**

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arises from the digastric impression on the inner surface of the body of the inferior maxilla, close to the base and symphysis.

Insertion.—The two bellies end upon an intervening tendon, about 2 inches long, which is inserted by means of a broad fibrous band into (1) the anterior surface of the body of the hyoid bone at its outer part, and (2) the adjacent portion of the great cornu.

Nerve-supply.—The posterior belly is supplied by the digastric branch of the facial nerve ; and the anterior belly derives its nerve-supply from the mylo-hyoid branch of the inferior dental, which is a branch of the inferior division of the fifth cranial nerve.

The posterior belly is directed downwards and forwards, and the anterior belly downwards and slightly outwards.

Action.—(1) To elevate the hyoid bone, as in the act of deglutition ; and (2) to depress the inferior maxilla.

Relations.—The **posterior belly** is at first deeply placed, being overhung by the mastoid process, and lying under cover of the trachelo-mastoid, splenius capitis, and sterno-cleido-mastoid muscles. It is also overlapped by the lower part of the parotid gland. It crosses the external and internal carotid arteries, internal jugular vein, and hypoglossal nerve. The stylo-hyoid muscle lies above it, and the hypoglossal nerve below it for a short distance. The intervening tendon is embraced by the fibres of the stylo-hyoid muscle. This tendon crosses the hypoglossal nerve, and forms two sides of a triangle, known as the **triangle of Lesser,** the base of which is directed upwards, and is formed by the hypoglossal nerve. In the area of this triangle is a portion of the hyo-glossus muscle, and beneath this part is a portion of the lingual artery. The **anterior belly,** which is shorter than the posterior, is covered by the integument, platysma myoides, and deep cervical fascia. It rests upon the mylo-hyoid muscle, and forms the lateral boundary of the submental triangle. Its inner border is connected with that of its fellow by a fascial expansion.

Stylo-hyoid—*Origin.*—The posterior and outer aspect of the styloid process of the temporal bone near its base.

Insertion.—The anterior surface of the hyoid bone at the junction of the body and great cornu.

Nerve-supply.—The stylo-hyoid branch of the facial nerve, which arises in common with the digastric branch.

The muscle is directed downwards and forwards.

Action.—To draw the hyoid bone upwards and backwards.

The muscle lies close above the posterior belly of the digastric, and, before taking insertion, it usually splits into two bundles, which embrace the intervening tendon of the digastric.

Mylo-hyoid—*Origin.*—The mylo-hyoid ridge, or internal oblique line, of the inferior maxilla.

Insertion.—The **posterior fibres** are inserted into the anterior surface of the body of the hyoid bone ; and the **principal part** of the muscle is inserted into a central fibrous raphé, which extends

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from the symphysis of the inferior maxilla on its deep and lower aspect to the body of the hyoid bone.

Nerve-supply.—The mylo-hyoid branch of the inferior dental nerve, which is a branch of the inferior maxillary division of the fifth cranial nerve.

The muscle is directed downwards and forwards.

Action.—(1) To raise the floor of the mouth, and, in doing so, to press the tongue against the hard palate, as in the first stage of the act of deglutition; (2) to elevate the hyoid bone, and draw it forwards; and (3) to depress the inferior maxilla.

The two mylo-hyoid muscles form a muscular floor for the buccal cavity, which is known as the *diaphragma oris*.

Relations—*Superficial or Inferior.*—The anterior belly of the digastric; the superficial part of the submaxillary gland, lodging a portion of the facial artery; and the mylo-hyoid nerve and submental branch of the facial artery.

Posterior Border.—Passing beneath the posterior free border of the muscle there are the following structures, in order from above downwards: (1) the lingual nerve; (2) a portion of the submaxillary gland; and (3) the hypoglossal nerve, and the ranine vein.

Deep or Superior.—The hyo-glossus muscle, and, resting upon it, (1) the lingual nerve, (2) the submaxillary ganglion, (3) the deep part of the submaxillary gland and Wharton's duct, (4) the hypoglossal nerve, and (5) the ranine vein. In front of the hyo-glossus is the genio-hyoid muscle, and between it and the hyo-glossus is a portion of the genio-hyo-glossus, with the sublingual gland resting upon it.

Genio-hyoid—*Origin.*—The lower genial spine of the inferior maxilla, close to the symphysis on its deep aspect.

Insertion.—The inner two-thirds of the anterior surface of the body of the hyoid bone over its upper part. At its insertion the muscle is divided externally into two laminæ, anterior and posterior, the former of which extends furthest out upon the hyoid bone. The innermost fibres of origin of the hyo-glossus pass inwards between these two laminæ.

Nerve-supply.—The hypoglossal nerve, the branch of which is regarded as being composed of spinal fibres.

The muscle is directed downwards and slightly backwards.

Action.—(1) To elevate the hyoid bone and draw it forwards, and (2) to depress the inferior maxilla.

The muscle is in intimate contact with its fellow of the opposite side at the median line. Its inferior or superficial surface is covered by the mylo-hyoid, and its superior or deep surface is related to the lower or posterior border of the genio-hyo-glossus.

Genio-hyo-glossus—*Origin.*—The upper genial spine of the inferior maxilla, close to the symphysis on its deep aspect.

Insertion.—(1) The under surface of the tongue close to the median line, and extending from near the tip to the root; (2) the inner part

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of the anterior surface of the body of the hyoid bone close to its upper margin ; and (3) slightly into the side of the pharynx, where the fibres blend with those of the middle constrictor muscle.

Nerve-supply.—The hypoglossal nerve, the branches of which enter the outer surface of the muscle.

The upper or anterior fibres arch upwards and forwards, and the lower downwards and backwards, whilst the intervening fibres spread out in a diverging manner.

Action.—(1) The entire glossal fibres depress the tongue at the

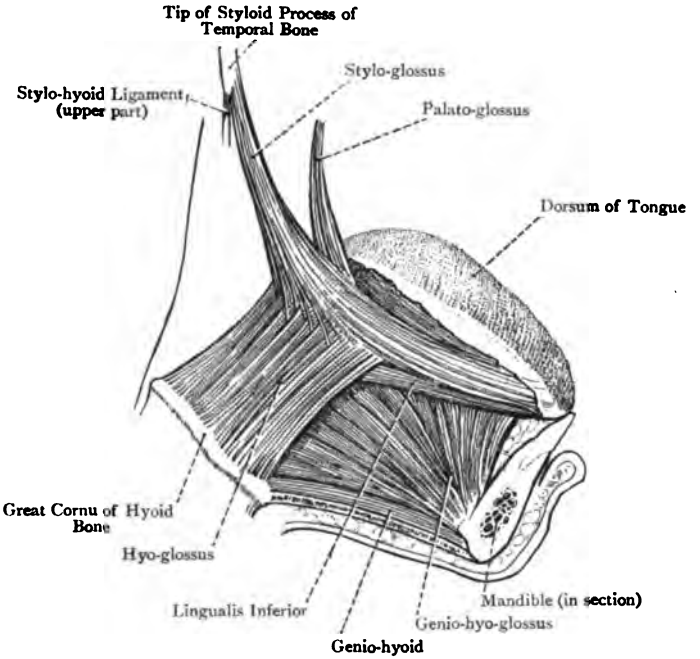

FIG. 445.—THE EXTRINSIC MUSCLES OF THE TONGUE. (THE LINGUALIS INFERIOR IS AN INTRINSIC MUSCLE).

median line, and, along with those of the opposite side, they give rise to an antero-posterior groove, or gutter, on the dorsum of the organ ; (2) the posterior glossal fibres draw forwards the tongue, so as to cause its tip to be protruded from the mouth ; (3) the anterior glossal fibres retract the tip of the tongue when it has been protruded from the mouth ; and (4) the lower or posterior (hyal) fibres elevate the hyoid bone, and draw it forwards.

The muscle is fan-shaped. The internal surface is closely applied to that of its fellow of the opposite side. The external surface is related to the inferior lingualis muscle, the ranine artery, the hyo-

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glossus and stylo-glossus muscles, and the sublingual gland. The upper or anterior border is covered by the buccal mucous membrane, and the lower or posterior border by the genio-hyoid muscle.

Hyo-glossus—*Origin.*—(1) The great cornu of the hyoid bone over its entire length; (2) the anterior surface of the body of the bone over about its outer half; and (3) the small cornu (inconstant). The innermost fibres of origin from the hyoid bone pass inwards between the two laminæ of the genio-hyoid muscle.

Insertion.—The posterior half of the under surface of the tongue close to its lateral border, the fibres being situated internal to those of the stylo-glossus, and both sets of fibres being intimately intermixed with each other and with the intrinsic lingual muscles.

Nerve-supply.—The hypoglossal nerve, the branches of which enter the superficial surface.

The muscle is for the most part directed upwards, but its anterior fibres have a slight inclination forwards.

Action.—(1) To depress the side of the tongue, and, along with its fellow, to render the dorsum of the organ convex; and (2) to assist in retracting the protruded tongue.

The hyo-glossus is a flat, four-sided muscle.

Relations—*Superficial.*—The mylo-hyoid muscle; the intervening tendon of the digastric, and stylo-hyoid muscle; the lingual nerve, with the submaxillary ganglion lying a little below it; the deep part of the submaxillary gland, and Wharton's duct; the hypoglossal nerve; and the ranine vein. *Posterior Border.*—The following structures pass beneath this border, in order from above downwards: (1) the glosso-pharyngeal nerve; (2) the stylo-hyoid ligament; and (3) the lingual artery. *Deep.*—The posterior part of the genio-hyo-glossus; a portion of the middle constrictor muscle of the pharynx; the lingual artery; the lower end of the stylo-hyoid ligament; and the glosso-pharyngeal nerve.

The fibres of the hyo-glossus which arise from the small cornu of the hyoid bone are separated from the rest of the muscle by those fibres of the genio-hyo-glossus which take insertion into the side of the pharynx, and they are regarded by some as a separate muscle, called the *chondro-glossus*. These fibres, however, are inconstant.

Stylo-glossus—*Origin.*—(1) The front of the styloid process of the temporal bone near its tip; and (2) the upper extremity of the stylo-mandibular ligament.

Insertion.—The under surface of the tongue close to its lateral border. The fibres extend as far forwards as the tip, and are situated external to the fibres of the hyo-glossus, both sets of fibres being intimately intermixed with each other, and with the intrinsic lingual muscles.

Nerve-supply.—The hypoglossal nerve.

The muscle is directed downwards, forwards, and inwards.

Action.—(1) To draw the tongue backwards; and (2) to elevate the root of the tongue.

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Stylo-hyoid Ligament.—This is a narrow fibrous cord which is attached superiorly to the tip of the styloid process, and inferiorly to the small cornu of the hyoid bone. Its direction is downwards and forwards, and its lower extremity is covered by the hyo-glossus muscle. It is liable to become ossified, more or less completely.

Submaxillary Gland.—This gland is situated in the anterior part of the submaxillary or digastric triangle. It consists of a large superficial part and a small deep part. The *superficial part* superiorly occupies the submaxillary fossa on the inner surface of the body of the inferior maxilla, and inferiorly it is covered by the skin, superficial fascia, platysma myoides, and deep fascia. The facial vein descends over it. Its deep surface rests anteriorly upon the mylo-hyoid muscle, with the intervention of the mylo-hyoid nerve and submental branch of the facial artery; and posteriorly upon the hyo-glossus, and slightly upon the posterior belly of the digastric and stylo-hyoid, muscles. The superficial part is grooved at its upper and back part by the facial artery, which lies embedded in the gland. Posteriorly the superficial part is related to the cervical portion of the parotid gland, from which it is separated by the stylo-mandibular (stylo-maxillary) ligament. The *deep part* of the gland is of small size, and is continuous with the superficial part at the posterior border of the mylo-hyoid muscle. It lies under cover of that muscle upon the hyo-glossus, and is related to the sublingual gland.

FIG. 446.—SECTION OF THE SUBMAXILLARY GLAND OF A DOG.

The **duct** of the submaxillary gland is known as **Wharton's duct,** and it emerges from the deep aspect of the superficial part of the gland close to the posterior border of the mylo-hyoid muscle. It is about 2 inches in length, and it passes inwards upon the hyo-glossus muscle, lying beneath the deep part of the gland. In this situation it has the submaxillary ganglion and lingual nerve above it, and the hypoglossal nerve below it. After leaving the hyo-glossus muscle, the duct lies upon the genio-hyo-glossus, and, passing slightly upwards, it is crossed from above downwards by the lingual nerve. Having passed beneath the sublingual gland, the duct opens upon the floor of the mouth by a minute orifice, which is situated on the summit of a papilla lying close to the side of the frenum of the tongue.

The submaxillary gland is enclosed in a capsule, which is derived from the deep cervical fascia.

Blood-supply.—The gland derives its blood chiefly from the cervical part of the facial artery.

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Nerve-supply.—The nerves are derived from the submaxillary ganglion, and through this from (1) the chorda tympani, (2) the lingual, and (3) the sympathetic plexus on the facial artery.

Lymphatics.—These pass to the submaxillary lymphatic glands, and thence to the superficial and deep cervical glands.

Structure.—The submaxillary gland is a **muco-serous gland,** and its general structure is similar to that of the parotid gland. The essential difference between the two has reference to the alveoli or acini, and the nature of their secretion. The cells of the parotid alveoli are *serous* or *albuminous*. The submaxillary alveoli contain, around the lumen, *mucous cells* filled with granular mucigen, which is discharged as mucus. They, however, also contain some albuminous cells, known as the *marginal cells*, which are situated, external

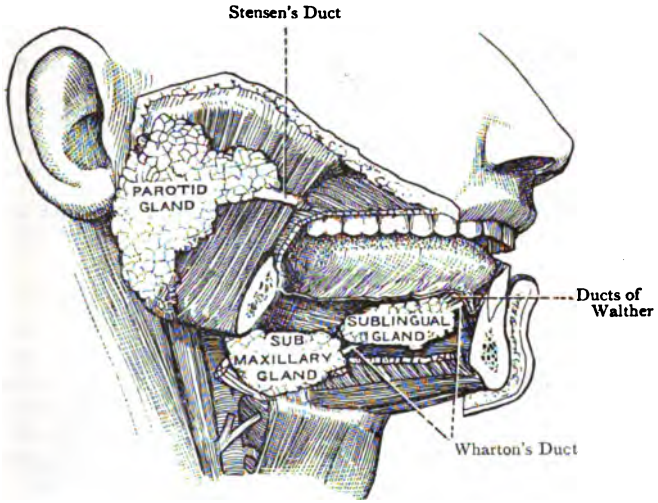

FIG. 447.—THE SALIVARY GLANDS OF THE RIGHT SIDE.

to the mucous cells, but within the membrana propria of the alveolus. These cells usually form groups which, from their crescentic arrangement, are known as the *crescents of Gianuzzi*.

Development.—The submaxillary gland is developed as a solid outgrowth of the buccal epithelium. This outgrowth undergoes ramifications, and these subsequently become hollow.

Sublingual Gland.—This is the smallest of the salivary glands, and resembles an almond in shape. It measures about 1½ inches in length, and is situated beneath the mucous membrane of the floor of the mouth, where it gives rise to a mucous fold, called the *plica sublingualis*. Inferiorly it rests upon the mylo-hyoid muscle (under cover of it), and is here related to the deep part of the submaxillary gland, Wharton's duct, and the lingual nerve. Externally it occupies the sublingual fossa on the inner surface of the body of the inferior maxilla above the mylo-hyoid ridge; and internally it is in contact with the genio-hyo-glossus muscle. Its mesial

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extremity comes into contact with its fellow of the opposite side over the anterior border of the genio-hyo-glossus muscle.

The **sublingual ducts** vary in number from ten to twenty, and are known as the *ducts of Walther* (ducts of Rivini). A few of them open into Wharton's duct, but the majority open in a linear manner upon the summit of the plica sublingualis. One of the ducts, called the *duct of Bartholin*, or *great duct of Rivini*, issues from the external lobule of the gland, and, accompanying Wharton's duct, it opens quite close to the orifice of that duct.

Blood-supply.—The gland derives its blood from the sublingual branch of the lingual, and the submental branch of the facial, arteries.

Nerve-supply.—The nerves are derived from the chorda tympani and lingual nerves, and the sympathetic plexus on the facial artery, through means of a branch of the submaxillary ganglion, which is conducted to the sublingual gland by the lingual nerve.

Structure.—The sublingual gland is a **mucous gland,** and its general structure is similar to that of the parotid and submaxillary glands, but the lobules are more loosely arranged. The cells of the sublingual alveoli are for the most part *mucous cells*, but there are also serous or albuminous cells.

Development.—The sublingual gland is developed as a solid outgrowth of the buccal epithelium. This outgrowth undergoes ramifications, and these subsequently become hollow.

Scalene Muscles and Subclavian Artery.

Scalene Muscles.—The scalene muscles are three in number, namely, scalenus anticus, scalenus medius, and scalenus posticus.

Scalenus Anticus—*Origin.*—By four short tapering tendons from the tubercles of the costal processes (anterior tubercles of the transverse processes) of the third, fourth, fifth, and sixth cervical vertebræ.

Insertion.—The scalene tubercle of the first rib.

Nerve-supply.—The anterior primary divisions of the fourth, fifth, and sixth cervical nerves.

The muscle is directed downwards, outwards, and forwards.

Action.—(1) To fix the first rib in ordinary inspiration, and to elevate it in forced inspiration; and (2) to flex the neck to one side and slightly forwards.

Chief Relations—*Anterior.*—The phrenic nerve, which crosses the muscle obliquely downwards and inwards; the internal jugular vein, which lies over its origin; and the subclavian vein close to its insertion. *Posterior.*—The scalenus medius, with the intervention of the second part of the subclavian artery, the nerve-roots of the brachial plexus, and the dome of the pleura. *Internal.*—The ascending cervical artery, and the origin of the rectus capitis anticus major.

Scalenus Medius—*Origin.*—By six short tapering tendons from the tubercles of the transverse processes (posterior tubercles) of the lower six cervical vertebræ.

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Insertion.—The upper surface of the first rib from the groove for the subclavian artery backwards to the tubercle.

Nerve-supply.—The anterior primary divisions of cervical nerves from the third to the eighth inclusive.

The muscle is directed downwards and outwards.

Action.—(1) To fix the first rib in ordinary inspiration, and (2) to flex the neck to one side.

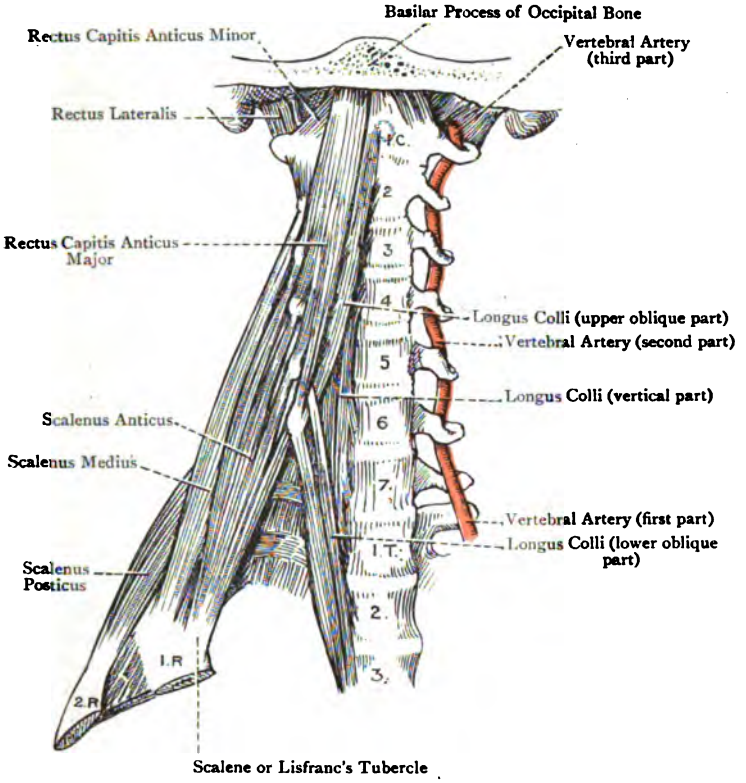

FIG. 448.—THE RIGHT PREVERTEBRAL MUSCLES.

(The Vertebral Artery is also shown).

Relations—*Anterior.*—The cervical plexus, the nerve-roots of the brachial plexus, except the first thoracic, and the second and third parts of the subclavian artery. *Posterior.*—The levator anguli scapulæ and scalenus posticus muscles.

The scalenus medius is pierced by the following nerves: (1) the nerve to the rhomboids, which passes in a backward direction; and (2) the upper and middle roots of the posterior thoracic nerve, or external respiratory nerve of Bell. These two roots usually emerge

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from the muscle as a single cord, and the lower or third root of the nerve descends in front of the scalenus medius, and joins the foregoing cord about the level of the first rib.

Scalenus Posticus—*Origin.*—By two or three short tendons from the tubercles of the transverse processes (posterior tubercles) of the lower two or three cervical vertebræ.

Insertion.—The upper part of the outer surface of the second rib, in front of the insertion of the highest slip of the serratus posticus superior, and behind the origin of a portion of the first, and the second, serrations of the serratus magnus.

Nerve-supply.—The anterior primary divisions of the sixth, seventh, and eighth cervical nerves, the branches of which pass through the scalenus medius.

The muscle is directed downwards and outwards.

Action.—(1) To elevate the second rib, and (2) to flex the neck to one side.

Relations—*Anterior.*—The scalenus medius. *Posterior.*—The lower two tendons of origin of the levator anguli scapulæ. The scalenus posticus is intimately connected with the scalenus medius, of which it may be regarded as a detached part.

Subclavian Artery.—The right subclavian vessel arises from the innominate artery behind the right sterno-clavicular joint on a level with its upper part, and the left subclavian vessel arises from the upper aspect of the arch of the aorta towards its back part. On each side the artery terminates at the outer border of the first rib by becoming the axillary artery. In its course the vessel is crossed superficially by the scalenus anticus muscle, which divides it into three parts, first, second, and third.

The **first part** extends from the origin of the vessel to the inner border of the scalenus anticus; the **second part** lies behind that muscle; and the **third part** extends from the outer border of the muscle to the outer border of the first rib. The total length of the vessel on the right side is about 3 inches, and, on the left, about 4½ inches. The artery describes an arch over the apex of the corresponding lung and pleura, and the height to which it rises above the clavicle is about ½ inch.

First Part of the Right Subclavian Artery.—This part extends from the bifurcation of the innominate artery behind the right sterno-clavicular joint, on a level with its upper part, to the inner border of the scalenus anticus muscle. Its direction is upwards and outwards, and it lies very deeply.

Relations—*Anterior.*—The skin, superficial fascia and platysma myoides, deep cervical fascia, clavicular origin of the sterno-cleido-mastoid, and sterno-hyoid and sterno-thyroid muscles. Three veins are related to it superficially. The internal jugular and vertebral veins cross it from above downwards close to the scalenus anticus, the latter vessel being under cover of the former, and the anterior jugular vein crosses it from within outwards, but superficial to the sterno-hyoid and sterno-thyroid muscles. Important

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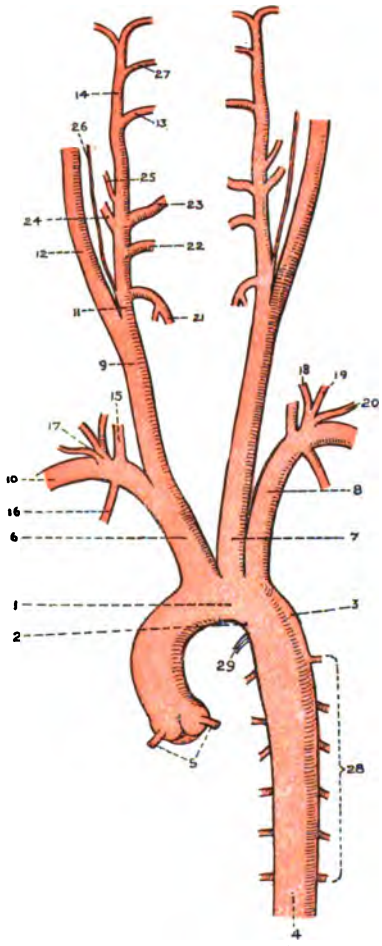

FIG. 449.—THE AORTA IN THE THORAX, AND THE PRINCIPAL ARTERIES OF THE HEAD AND NECK.

1. Arch of the Aorta
2. Aortic Isthmus
3. Aortic Spindle
4. Descending Aorta
5. Coronary Arteries (from Ascending Aorta)
6. Innominate Artery
7. Left Common Carotid
8. Left Subclavian
9. Right Common Carotid
10. Right Subclavian
11. External Carotid
12. Internal Carotid
13. Internal Maxillary
14. Superficial Temporal
15. Vertebral
16. Internal Mammary
17. Thyroid Axis
18. Inferior Thyroid
19. Transverse Cervical
20. Suprascapular
21. Superior Thyroid
22. Lingual
23. Facial
24. Occipital
25. Posterior Auricular
26. Ascending Pharyngeal
27. Transverse Facial
28. Aortic Intercostals
29. Lig. Ductûs Arteriosi

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nerves also cross it superficially, namely, the pneumogastric and its cervical cardiac branches, the cervical cardiac branches of the sympathetic, and the nerve-loop known as the ansa Vieussenii. *Posterior.*—The recurrent laryngeal nerve, gangliated cord of the sympathetic, fat, longus colli muscle, first thoracic vertebra, dome of the pleura, and apex of the lung. *Inferior.*—The recurrent laryngeal nerve, part of the ansa Vieussenii, and the pleura.

The right subclavian and right internal jugular veins unite anterior to this part of the vessel to form the right innominate vein.

First Part of the Left Subclavian Artery.—This part extends from the upper aspect of the arch of the aorta, towards its back part, to the inner border of the scalenus anticus muscle. It is therefore placed at first in the thoracic cavity. Its course is almost vertical until it reaches the root of the neck, where it curves sharply outwards upon the dome of the pleura, and so reaches the scalenus anticus. The relations of the intrathoracic portion have been described in connection with the thorax (see p. 904).

Cervical Relations—*Anterior.*—The skin, superficial fascia and platysma myoides, deep cervical fascia, clavicular origin of the sterno-cleido-mastoid, sterno-hyoid and sterno-thyroid muscles, and the thoracic duct which arches over it. The left internal jugular and subclavian veins unite in front of it to form the left innominate vein, and the left vertebral vein descends in front of it under cover of the left internal jugular vein. *Posterior.*—The gangliated cord of the left sympathetic with the inferior cervical ganglion, fat, and the left longus colli muscle. *Right.*—The trachea, œsophagus, left recurrent laryngeal nerve, and thoracic duct.

The varieties in origin of the subclavian artery have been described in connection with the arch of the aorta (see p. 906).

Second Part of the Subclavian Artery.—This portion of the vessel is situated behind the scalenus anticus muscle. It lies about ½ inch above the clavicle, and forms the highest part of the arch described by the vessel.

Relations—*Anterior.*—The skin, superficial fascia and platysma myoides, deep cervical fascia, clavicular part of the sterno-cleido-mastoid, scalenus anticus, phrenic nerve on the right side, and subclavian vein, the latter vessel being on a lower level than the artery, and separated from it by the scalenus anticus. *Posterior.*—The pleura. *Superior.*—The nerve-roots of the brachial plexus. *Inferior.*—The pleura.

In some cases the second part of the vessel passes through the scalenus anticus, and in rare cases it passes in front of the muscle.

For the third part of the subclavian artery, see p. 1020.

Development.—The *right* subclavian artery, as far as the origin of the internal mammary artery, is developed from the fourth right arterial arch.

The *left* subclavian artery is developed from a segmental artery.

Branches of the Subclavian Artery.—These are four in number, namely, the vertebral, internal mammary, thyroid axis, and

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superior intercostal. The first three arise from the *first part* of the artery towards its termination, and the last arises from the *second part* on the **right** side, and from the *first part* on the **left** side.

Vertebral Artery.—This is the first branch in order. On the right side it arises from the upper and back part of the artery about an inch from its origin, and on the left side from the vessel just after it enters the root of the neck. It passes for a short distance upwards, backwards, and slightly outwards, and disappears from view by entering through the costo-transverse (vertebrarterial) foramen in the transverse process of the sixth cervical vertebra as a rule. It then ascends vertically through the successive costo-transverse foramina above that of the sixth vertebra, and in passing from that of the axis to that of the atlas it describes a bend outwards. Having traversed the costo-transverse foramen of the atlas, it passes backwards and inwards, lying in the vertebrarterial groove on the upper surface of the posterior arch of the atlas behind the superior articular process. Thereafter it pierces the dura mater and arachnoid, and, having reached the side of the spinal cord, it turns upwards in the subarachnoid space, and enters the cranial cavity through the foramen magnum. Being now related to the medulla oblongata, it gradually inclines from its lateral to its ventral aspect, and at the lower border of the pons Varolii it joins its fellow to form the basilar artery.

On account of its complicated course, the vertebral artery is divided into four parts, namely, first or cervical, second or costo-transverse, third or suboccipital, and fourth or intracranial.

The **first** or **cervical part** extends from the origin of the vessel to the costo-transverse foramen in the transverse process of the sixth cervical vertebra. It lies between the scalenus anticus and longus colli muscles, having the internal jugular and vertebral veins in front of it; being crossed by the inferior thyroid artery; and having the sympathetic gangliated cord and the transverse process of the seventh cervical vertebra behind it. The vessel of the left side has the thoracic duct as an additional anterior relation.

The first part gives off no branches.

The **second** or **costo-transverse part** traverses the costo-transverse foramina of the cervical vertebræ from, as a rule, the sixth upwards. It is surrounded by the vertebral venous plexus, and by the vertebral plexus of the sympathetic, and it lies in front of the cervical spinal nerves as these emerge from the intervertebral foramina.

Branches.—These are as follows: lateral spinal and muscular. The *lateral spinal branches* enter the spinal canal through the intervertebral foramina. The *muscular branches* supply the deep muscles of the neck, and anastomose with the deep cervical, ascending cervical, and occipital arteries.

For the third or suboccipital, and the fourth or intracranial, parts of the vertebral artery, see pp. 990, 1346).

Varieties.—(1) The left vertebral artery occasionally arises from the arch of the aorta between the origins of the left common carotid and left subclavian

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arteries. (2) The vessel may pass the costo-transverse foramen of the sixth cervical vertebra, and may enter that of the fifth, or even that of the fourth. (3) The vessel has been found in rare cases to enter the costo-transverse foramen of the seventh cervical vertebra.

Internal Mammary Artery.—This vessel is so named in contradistinction to the *external mammary*, or *long thoracic*, which is a branch of the second part of the axillary artery. It arises from the lower aspect of the first part of the subclavian artery very nearly opposite the thyroid axis. Its course is downwards, forwards, and slightly inwards, and it disappears behind the sternal end of the clavicle and first costal cartilage. For its subsequent course and relations, see p. 875.

Relations of Cervical Part—*Anterior.*—The clavicular part of the sterno-cleido-mastoid, and the internal jugular and subclavian veins. The phrenic nerve crosses the vessel superficially from without inwards. *Posterior.*—The pleura.

No branches arise from this part of the vessel.

Thyroid Axis.—This is a short trunk which springs from the front of the first part of the subclavian artery close to the inner border of the scalenus anticus muscle. It almost immediately divides into three diverging branches, namely, inferior thyroid, transverse cervical, and suprascapular.

The **inferior thyroid artery** passes upwards and inwards in a tortuous manner in front of the vertebral artery, and behind the carotid sheath and sympathetic nerve, the middle cervical ganglion of which latter rests upon it. Having reached the lower part of the lateral lobe of the thyroid body, the artery breaks up into its terminal branches, which enter the lobe on its deep aspect, and ramify in it, anastomosing with the superior thyroid, and with its fellow of the opposite side in the isthmus. As the vessel ascends it is intimately related to the recurrent laryngeal nerve, which usually lies behind it.

Branches.—These are as follows: muscular, ascending cervical, inferior laryngeal, tracheal, and œsophageal.

The *muscular branches* supply the scalenus anticus, longus colli, depressor muscles of the hyoid bone, and inferior constrictor of the pharynx. The *ascending cervical artery* arises from the inferior thyroid as it passes inwards behind the carotid sheath. It ascends in front of the transverse processes of the cervical vertebræ, lying between the scalenus anticus and rectus capitis anticus major, and having the phrenic nerve on its outer side. It anastomoses with branches of the vertebral, occipital, and ascending pharyngeal arteries. It may furnish some spinal branches which enter the spinal canal through the intervertebral foramina, to be distributed in a manner similar to the other spinal arteries. The *inferior laryngeal artery* accompanies the recurrent laryngeal nerve to the larynx. The *tracheal* and *œsophageal* branches are distributed as their names suggest.

The **transverse cervical artery** passes transversely outwards in front of the scalenus anticus and phrenic nerve, and behind the

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clavicular part of the sterno-cleido-mastoid, lying a little above the clavicle, and also above the suprascapular artery. It then enters the subclavian triangle, which it soon leaves by passing beneath the posterior belly of the omo-hyoid. Thereafter it passes in front of, or between, the nerve-trunks of the brachial plexus, and beneath the trapezius muscle. Having reached the anterior border of the levator anguli scapulæ, it divides into its two terminal branches—superficial cervical and posterior scapular.

The *superficial cervical artery* passes superficial to the levator anguli scapulæ, and is distributed to the trapezius, levator anguli scapulæ, splenius, and the adjacent lymphatic glands. The *posterior scapular artery* passes backwards beneath the levator anguli scapulæ to the superior angle of the scapula. Thereafter it descends along the base of the bone, under cover of the rhomboid muscles, as far as the lower angle, where it anastomoses with the teres branch of the dorsalis scapulæ of the subscapular from the third part of the axillary artery. The artery gives branches to the adjacent muscles, and ventral and dorsal branches to the scapula, which take part in the scapular anastomoses proper (see p. 304).

The posterior scapular artery is frequently a branch of the third part of the subclavian, in which cases there is no transverse cervical artery, the superficial cervical artery taking its place and arising from the thyroid axis.

The **suprascapular artery** (transversalis humeri) passes downwards and outwards in front of the scalenus anticus and phrenic nerve, and behind the clavicular part of the sterno-cleido-mastoid. Having reached the back of the clavicle, it courses outwards behind that bone, passing in front of the third part of the subclavian artery and the trunks of the brachial plexus. It then passes to the upper border of the scapula, in company with the suprascapular nerve. For the further course of the vessel see p. 300; and for the scapular anastomoses of arteries see p. 304.

Branches in the Neck.—These are as follows: muscular, suprasternal, and medullary. The *muscular branches* supply the sterno-cleido-mastoid and subclavius. The *suprasternal branch* descends over the inner end of the clavicle to supply the integument over the manubrium sterni. The *medullary artery* of the clavicle is directed *outwards*, and enters the medullary foramen of that bone.

Superior Intercostal Artery.—This vessel arises from the second part of the subclavian on the right side, and from the first part on the left side, in each case from the posterior aspect of the parent trunk. On the right side it is therefore behind the scalenus anticus, and on the left side close to the inner border of that muscle. The vessel at first passes backwards for a short distance, and then descends in front of the neck of the first rib. At the posterior extremity of the first intercostal space it furnishes the first intercostal artery to that space, and then descends in front of the neck of the second rib to become the second intercostal artery. The superior intercostal artery, therefore, furnishes the first and second

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intercostal arteries for the first and second intercostal spaces, their distribution being similar to that of the succeeding aortic intercostal arteries. Besides these two branches, the vessel gives off the *deep cervical artery*. This branch, which is homologous with the dorsal branch of an aortic intercostal artery, arises from the superior intercostal before it descends in front of the neck of the first rib. It passes backwards between the transverse process of the seventh cervical vertebra and the neck of the first rib, and then ascends between the complexus and semispinalis colli muscles to about the level of the axis. In this latter situation it anastomoses with the deep branch of the ramus cervicalis princeps of the occipital from the external carotid. The deep cervical in its course gives off muscular branches which anastomose with branches of the vertebral and ascending cervical arteries. It also furnishes a spinal branch which enters the spinal canal through the intervertebral foramen between the seventh cervical and first thoracic vertebræ.

The first part of the right subclavian artery sometimes gives off a small branch, which is known as the **aberrant artery.** It arises near the vertebral, or sometimes from the superior intercostal, and passes obliquely downwards and inwards between the œsophagus and the vertebral column. In the thorax it ends by joining the back of the arch of the aorta close to its termination, or by anastomosing with an offset from that part of the arch. The vas aberrans is regarded as representing the remains of the right aortic root, and an enlargement of it would account for the rare origin of the right subclavian artery from the back part of the aortic arch near its termination, and for the course of the abnormal vessel behind the œsophagus as it passes to take up its position on the right side.

Subclavian Vein.—This vessel, which is the direct continuation of the axillary vein, extends from the outer border of the first rib to the back of the inner end of the clavicle, where it unites with the internal jugular to form the innominate vein. It lies in front of, and on a lower plane than, the subclavian artery, and it passes in front of the scalenus anticus muscle and phrenic nerve. In rare cases the vein has been met with passing behind the scalenus anticus. Its principal tributary is the external jugular vein (sometimes also the anterior jugular). The external jugular vein joins it close to the outer border of the sterno-cleido-mastoid.

The thoracic duct opens in the angle of junction of the left subclavian and left internal jugular veins, and the right lymphatic duct opens into the angle of junction of the corresponding veins on the right side.

Vertebral Vein.—This vein commences in the suboccipital venous plexus within the suboccipital triangle. It passes through the costo-transverse foramen in the altas, and accompanies the vertebral artery through the succeeding costo-transverse foramina as low as the sixth, forming a plexus around the vessel. This plexus is ultimately replaced by a single vein, which emerges through the costo-transverse foramen in the sixth cervical vertebra (sometimes the seventh). It then descends in front of the first part of the subclavian artery, under cover of the internal jugular vein, and

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opens into the back part of the innominate vein, the opening being provided with a single or double valve.

The **chief tributaries** of the vertebral vein are as follows: muscular, spinal, anterior vertebral, and deep cervical. It also, as a rule, receives the first intercostal vein.

No vein accompanies the cervical part of the internal mammary artery. The **inferior thyroid vein,** which does not accompany the corresponding artery, will be found described in connection with the thyroid body (see p. 1048).

The **transverse cervical** and **suprascapular veins** return the blood from the parts supplied by the corresponding arteries, and are tributaries of the lower part of the external jugular vein.

The **deep cervical vein** (posterior vertebral vein) commences in the suboccipital venous plexus within the suboccipital triangle. It descends in company with the deep cervical artery, and passes forwards between the transverse process of the seventh cervical vertebra and the neck of the first rib to terminate in the vertebral vein.

The **anterior vertebral vein** commences in a plexus in front of the upper cervical transverse processes. It descends in company with the ascending cervical branch of the inferior thyroid artery, receiving muscular tributaries in its descent, and it opens into the lower part of the vertebral vein.

Collateral Circulation after Ligation of the Third Part of the Subclavian Artery.—(1) The suprascapular and the posterior scapular branch of the transverse cervical, both branches of the thyroid axis from the first part of the subclavian, take part in the scapular anastomoses, and anastomose freely with branches of the first and third parts of the axillary artery. (2) The internal mammary from the first part of the subclavian anastomoses with the long thoracic from the second part of the axillary.

Collateral Circulation after Occlusion of the First Part of the Subclavian Artery.—(1) The vertebral artery of one side anastomoses with that of the opposite side. (2) The internal mammary anastomoses with the deep epigastric from the external iliac, and with the aortic intercostal arteries. (3) The inferior thyroid anastomoses with the superior thyroid from the external carotid. (4) The superior intercostal anastomoses with the first aortic intercostal. (5) The deep cervical of the superior intercostal anastomoses with the deep branch of the ramus cervicalis princeps of the occipital from the external carotid. (6) The scapular branches of the thyroid axis anastomose with branches of the axillary artery. (7) The thoracic branches of the axillary artery anastomose with the aortic intercostals.

Cervical Part of the Thoracic Duct.—This part of the thoracic duct occupies the root of the neck on the *left side*, and lies upon the side of the œsophagus, between the left common carotid and left subclavian arteries. In this position it ascends to about the level of the seventh cervical vertebra, and then it describes a

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curve and passes outwards, forwards, and downwards in contact with the dome of the left pleura. Thereafter it inclines inwards, and, after receiving the left jugular and axillary lymphatic trunks, terminates in the angle of junction of the internal jugular and subclavian veins of the left side. The terminal orifice of the duct is guarded by a valve composed of two segments, which are so directed as to effectually prevent the reflux of chyle, and the flow of blood, into it. The duct crosses the left verterbal artery, and subsequently the left subclavian artery.

Right Lymphatic Duct.—The position of this duct corresponds to that of the thoracic duct on the left side. It is about ½ inch in length, and is formed by the union of the right axillary lymphatic trunk and right jugular lymphatic trunk. Besides returning lymph from the right side of the head and neck and the right upper limb, it receives the lymphatic vessels from the right side of the heart, the right lung, the upper part of the right half of the thoracic wall, and some of those from the supero-anterior surface of the liver. It terminates in the angle of junction of the internal jugular and subclavian veins of the corresponding side, its orifice being guarded by a double valve.

Cervical Portion of the Lung —The apex of the lung projects into the root of the neck for from 1 to 1½ inches. It is covered by the dome of the pleura, on the inner and anterior aspects of which the subclavian artery arches outwards. The dome of the pleura is covered by **Sibson's fascia,** which extends from the internal border of the first rib to the front of the transverse process of the seventh cervical vertebra. This fascia is probably derived from the adjacent scalene muscles, and it may contain some muscular fibres.

The Orbit.

The contents of the orbit are as follows : (1) the eyeball and the optic nerve ; (2) the capsule of Tenon ; (3) seven muscles, six of which belong to the eyeball, namely, the four recti and two obliqui, whilst the seventh belongs to the upper eyelid, and is called the levator palpebræ superioris ; (4) the third, fourth, and sixth cranial nerves, the three branches of the ophthalmic division of the fifth cranial nerve, namely, frontal, lachrymal, and nasal, and the orbital or temporo-malar branch of the superior maxillary division of the fifth cranial nerve ; (5) the ciliary, lenticular, or ophthalmic ganglion ; (6) the lachrymal gland ; and (7) a quantity of soft fat. The foregoing contents are surrounded by a fibrous sheath which is formed by the periosteum.

Periosteum.—The periosteum of the orbit is continuous posteriorly with the dura mater through the sphenoidal fissure. Anteriorly it becomes continuous with the pericranium of the frontal bone, and the periosteum of the superior maxillary and malar bones. Along the supra-orbital and infra-orbital margins the superior and inferior palpebral ligaments blend with it. The

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periosteum is loosely attached to the bony walls of the orbit, and forms a sheath for the contents of the cavity, which is incomplete in front.

Lachrymal Gland.—This gland lies at the anterior and outer part of the orbit superiorly, where it occupies the lachrymal fossa on the inner side of the external angular process of the frontal bones. It is almond-shaped. Its upper surface is convex, and its under surface is concave in adaptation to the eyeball. The anterior part of the gland is more or less detached, and is known as the *palpebral portion*, the chief part being known as the *orbital portion*. The **ducts**, which issue from both portions, are about twelve in number, and they open in a row into the outer part of the superior *fornix conjunctivæ*.

Blood-supply.—The lachrymal artery.

Nerve-supply.—The lachrymal nerve, and sympathetic filaments.

The **structure** of the gland is similar to that of the parotid gland.

Muscles.—These are seven in number, as follows: levator palpebræ superioris, superior rectus, inferior rectus, internal rectus, external rectus, superior oblique, and inferior oblique.

Levator Palpebræ Superioris—*Origin.*—The under surface of the roof of the orbit above, and in front of, the optic foramen.

Insertion.—By a broad membranous expansion, which divides into three layers. The *middle layer*, which represents the chief insertion, and consists largely of involuntary muscular fibres, is attached to the upper margin of the superior tarsal plate. The *upper* or *superficial layer*, which is fibrous, passes over, or in front of, the superior tarsal plate, lying between it and the palpebral fibres of the orbicularis palpebrarum. Its fibres pierce the superior palpebral ligament, and, having passed between the bundles of the palpebral portion of the orbicularis palpebrarum, they are attached to the skin of the upper eyelid. The *lower* or *deep layer*, which is also fibrous, is attached to the conjunctiva along the superior fornix. The outer and inner margins of the broad membranous expansion are attached to the outer and inner margins of the orbit close to the external and internal tarsal ligaments, and at the inner angle a slip is detached to the pulley of the superior oblique muscle.

Nerve-supply.—The upper division of the third cranial nerve, the branch from which enters the deep or ocular surface of the muscle near its origin.

Action.—To raise the upper eyelid. The muscle is the antagonist of the superior palpebral fibres of the orbicularis palpebrarum.

Relations.—*Superiorly*, the frontal nerve and the supra-orbital artery. *Inferiorly*, the superior rectus and the conjunctiva.

Recti Muscles—Superior Rectus—*Origin.*—The upper part of the fibrous ring in relation to the optic foramen.

Insertion.—By a thin expanded tendon into the upper surface of the sclerotic about three or four lines from the margin of the cornea.

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Nerve-supply.—The upper division of the third cranial nerve, the branch from which enters the deep or ocular surface of the muscle near its origin.

The muscle is flattened from above downwards, and its direction is forwards and slightly outwards.

Action.—To elevate the eyeball, so as to direct the cornea upwards. The muscle imparts a certain amount of inward movement to the eyeball, accompanied by slight rotation.

Relations.—*Superiorly*, the levator palpebræ superioris, which is the narrower of the two muscles. *Inferiorly*, the soft fat of the orbit.

Internal Rectus—*Origin.*—The upper and lower parts of the fibrous ring in relation to the optic foramen, the origin being wide,

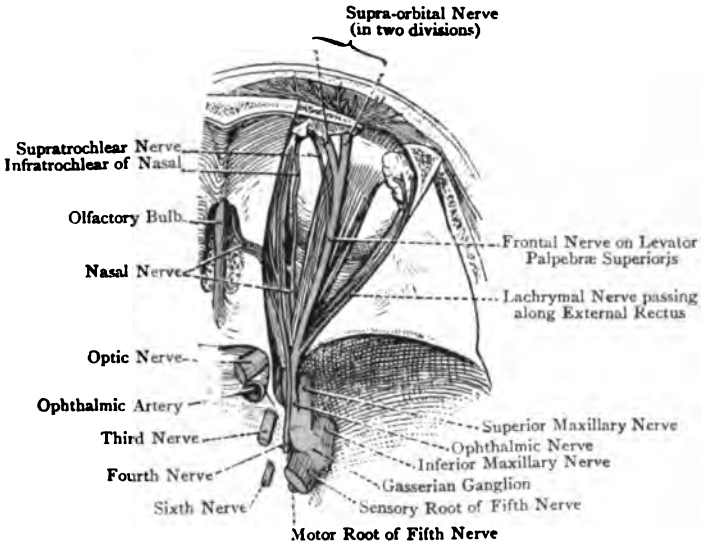

FIG. 450.—DISSECTION OF THE ORBIT FROM ABOVE (HIRSCHFELD AND LEVEILLÉ).

and being situated partly on the inner side of, and partly below, the optic foramen.

Insertion.—By a thin expanded tendon into the inner surface of the sclerotic about three or four lines from the margin of the cornea.

Nerve-supply.—The lower division of the third cranial nerve, the branch from which enters the deep or ocular surface of the muscle.

The muscle is flattened from within outwards, and its borders are superior and inferior. Its direction is almost straight forwards.

Action.—To adduct the eyeball, so as to direct the cornea inwards.

Relations.—Above the upper border of the muscle is the superior oblique, and between the two the nasal nerve and the anterior and posterior ethmoidal vessels pass.

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Inferior Rectus—*Origin.*—The lower part of the fibrous ring in relation to the optic foramen.

Insertion.—By a thin expanded tendon into the lower surface of the sclerotic about three or four lines from the margin of the cornea.

Nerve-supply.—The lower division of the third cranial nerve, the branch from which enters the deep or ocular surface of the muscle.

The muscle is flattened from above downwards, and its direction is forwards and slightly outwards.

Action.—To depress the eyeball, so as to direct the cornea downwards. The muscle imparts a certain amount of inward movement to the eyeball, accompanied by slight rotation.

Relations—*Inferior.*—A part of the inferior oblique.

External Rectus—*Origin.*—This muscle arises by two heads.

Inferior Head.—(1) The lower part of the fibrous ring in relation to the optic foramen, where it is contiguous to the inferior rectus; and (2) the prominent spine on the lower margin of the sphenoidal fissure near its inner end.

Superior Head.—The outer portion of the upper part of the fibrous ring in relation to the optic foramen, where it is above the sphenoidal fissure, external to the optic foramen, and contiguous to the superior rectus. The two heads are connected by a tendinous band which arches over the sphenoidal fissure, and gives origin to some of the fibres of the inferior head of the muscle.

Insertion.—The outer surface of the sclerotic from three to four lines from the margin of the cornea.

Nerve-supply.—The sixth cranial nerve, the branches of which enter the deep or ocular surface of the muscle.

The muscle is flattened from without inwards, and its direction is forwards and outwards.

Action.—To abduct the eyeball, so as to direct the cornea outwards.

Relations.—The following structures pass between the two heads of the muscle, in order from above downwards: (1) the upper division of the third nerve; (2) the nasal nerve; (3) the lower division of the third nerve; (4) the sixth nerve; and (5) the ophthalmic vein, or veins.

Common Tendon of the Recti Muscles.—This tendon takes the form of a fibrous ring, which is attached to the upper, inner, and lower margins of the optic foramen. It then crosses transversely the inner portion of the sphenoidal fissure to a prominent spine on the lower margin of that fissure near its inner end. From this spine it recrosses the sphenoidal fissure in a vertical direction near its centre, and finally reaches the upper part of the optic foramen. This latter portion gives origin to some fibres of the inferior head of the external rectus. The fibrous ring presents an upper and a lower part. The *upper part* is prolonged forwards into the *superior tendon of Lockwood*, which gives origin from within outwards to part of the internal rectus, the superior rectus, and the superior head of the external rectus. The *lower part* is also

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prolonged forwards into the *inferior tendon* or *ligament of Zinn*, which gives origin from within outwards to part of the internal rectus, the inferior rectus, and the inferior head of the external rectus.

Obliqui Muscles—Superior Oblique—*Origin.*—The wall of the orbit directly in front of the upper and inner part of the optic foramen, where it is contiguous to the superior and internal recti.

Insertion.—By an expanded tendon into the upper and outer aspect of the sclerotic, just beyond the outer border of the superior rectus, and midway between the margin of the cornea and the entrance of the optic nerve.

The muscle is situated at the upper and inner part of the orbit, internal to the levator palpebræ superioris. It is directed forwards towards the inner angle of the orbit, on approaching which it ends in a small round tendon. This tendon passes over a fibro-cartilaginous pulley or trochlea, close to the internal angular process of the frontal bone. Thereafter it changes its direction, and passes downwards, outwards, and backwards beneath the tendon of the superior rectus to reach its insertion just external to that tendon.

The fibro-cartilaginous pulley or *trochlea* is attached by fibrous tissue to the *fovea trochlearis* on the orbital plate of the frontal bone close to the internal angular process. It is lined with synovial membrane to lubricate the tendon and facilitate its movement at this abrupt change in its course. The tendon receives a fibrous investment from the outer margin of the pulley.

Nerve-supply.—The fourth cranial nerve, which enters the muscle on its *superficial* or *orbital surface* near its origin.

Action.—To depress and abduct the eyeball, or turn it outwards, the eyeball being at the same time slightly rotated.

Relations—*Superior* —The roof of the orbit and the superior rectus. *Inferior.*—The upper border of the internal rectus, with the intervention of the nasal nerve, and the anterior and posterior ethmoidal vessels. *External.*—The levator palpebræ superioris.

Inferior Oblique—*Origin.*—A small depression at the anterior and inner part of the floor of the orbit, immediately external to the upper opening of the lachrymal canal.

Insertion.—The outer surface of the sclerotic under cover of the external rectus, and slightly posterior to the level of the insertion of the superior oblique.

Nerve-supply.—The lower division of the third cranial nerve, the branch of which is long and enters the *posterior border* of the muscle.

The muscle at first passes outwards and backwards upon the floor of the orbit beneath the inferior rectus, and then it turns upwards between the sclerotic and the external rectus, where its tendon expands before taking insertion.

Action.—To elevate and abduct the cornea, the eyeball being at the same time slightly rotated.

Relations.—Towards the eyeball the muscle is related to the inferior rectus and the sclerotic, and towards the orbit to the floor

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of the cavity and the external rectus. The borders of the muscle are anterior and posterior, the latter, as stated, receiving the nerve-supply.

Movements of the Eyeball.—The movements of the eyeball consist of rotation round a point situated just behind the centre of its antero-posterior axis. When the eyeball rotates round its vertical axis horizontal or lateral movements take place, and the cornea is directed outwards or inwards according to the muscle which acts. The external rectus abducts the eyeball, so as to direct the cornea outwards, and the internal rectus adducts the eyeball, so as to direct the cornea inwards. When the eyeball rotates round its transverse axis vertical or upward and downward movements take place, and the cornea is directed upwards or downwards according to the muscle which acts. The superior rectus elevates the eyeball, and the inferior rectus depresses it. It is to be borne in mind, however, that these two muscles in passing forwards have each a slight inclination *outwards*. Whilst, then, they respectively elevate and depress the eyeball, each of them also imparts to it a certain amount of inward movement, accompanied by slight rotation. In the case of the superior rectus this inward and rotatory movement is corrected by the *inferior oblique* acting in association with it, and in the case of the inferior rectus by the *superior oblique* acting in association with it.

Direct elevation of the eyeball is therefore effected by the superior rectus, aided by the inferior oblique, and *direct depression* of the eyeball is effected by the inferior rectus, aided by the superior oblique. The superior oblique, acting alone, depresses the eyeball, and abducts it, or turns it outwards, and the inferior oblique, acting alone, elevates the eyeball, and abducts it, these movements in each case being accompanied by slight rotation.

Fascia of the Orbit.—This fascia forms (1) the capsule of Tenon, and (2) sheaths for the ocular muscles.

The **capsule of Tenon** forms a connective-tissue covering for the sclerotic coat of the eyeball, and extends from the point of entrance of the optic nerve to near the margin of the cornea. *Posteriorly* it is perforated by the ciliary vessels and nerves, and blends with the dura matral sheath of the optic nerve, and *anteriorly* it passes beneath the ocular conjunctiva, with which it unites near the margin of the cornea. The outer surface of the capsule is in contact with the orbital fat, and anteriorly with the ocular conjunctiva. The inner surface, which is smooth, is separated from the sclerotic by a narrow space, which is crossed by delicate trabeculæ of connective tissue. This interspace is called the **perisclerotic space,** or **Tenon's space,** and is regarded as a lymph space. The capsule of Tenon forms a cavity or socket, within which the eyeball glides with perfect freedom from friction.

The lower part of the capsule of Tenon presents a thickening, which is known as the **suspensory ligament of the eye** (Lockwood). It is attached externally to the malar bone, and internally to the

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lachrymal bone, in association with the forward expansions from the sheaths of the external and internal recti muscles. It is expanded beneath the eyeball, to the fore part of which it acts as a sling or support.

The **muscular sheaths** are derived from the capsule of Tenon. The tendons of the six ocular muscles pierce the capsule on their way to their insertions, which latter are under cover of the capsule, each muscle receiving a prolongation from the margin of the cleft in the capsule of Tenon through which its tendon passes. These prolongations extend backwards around the muscles, and ultimately blend with their perimysial sheaths. As regards the superior oblique muscle, the prolongation around its tendon extends upwards, inwards, and forwards as far as the margin of the trochlea, to which it is attached. The prolongation around the tendon of the inferior oblique muscle extends downwards as far as the outer part of the floor of the orbit.

The sheaths of the four recti muscles give off important expansions. The expansion from the sheath of the external rectus is strong, and is attached to the orbital process of the malar bone, and that from the sheath of the internal rectus, also strong, is attached to the lachrymal crest of the lachrymal bone. These two expansions, at their bony attachments, are connected with the lateral extremities of Lockwood's suspensory ligament. The expansion from the sheath of the superior rectus blends with the deep layer of the tendon of the levator palpebræ superioris, and that from the sheath of the inferior rectus is connected with the inferior tarsal plate. These expansions from the sheaths of the recti, especially from those of the external and internal recti, moderate the action of the muscles, and the latter two are hence known as the **check ligaments.**

Nerves in the Orbit—Optic Nerve.—The optic nerve extends forwards and outwards from the optic commissure, and enters the orbit through the optic foramen, having the ophthalmic artery below it at first, and then on its outer side. It receives sheaths from the dura mater and arachnoid, the former being strong, and at its entrance into the orbit it is surrounded by the origins of the four recti muscles. Its direction is forwards and outwards, with a slight inclination downwards, to the back part of the eyeball, where it pierces the sclerotic coat about $\frac{1}{8}$ inch internal to, and a little below, the level of the centre. Thereafter it pierces the choroid coat, and terminates in the nerve fibre-layer of the retina. The lenticular or ciliary ganglion is in close contact with the outer side of the nerve towards the back part of the orbit, and anterior to this the nerve is surrounded by the ciliary nerves and vessels. It is crossed superiorly by the ophthalmic artery, the superior ophthalmic vein, and the nasal nerve. Inferiorly, about $\frac{1}{2}$ inch behind the eyeball, the arteria centralis retinæ enters it as far as the centre, and thereafter runs forward within it to the retina.

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Third, or **Oculo-motor, Nerve.**—This nerve, having left the outer wall of the cavernous sinus, breaks up at the sphenoidal fissure into two divisions, upper and lower. These enter the orbit between the two heads of the external rectus muscle, the nasal nerve being situated between the two.

The *upper division* furnishes two branches, which supply the levator palpebræ superioris and the superior rectus, the twigs entering the muscles on their deep or ocular surfaces.

The *lower division*, larger than the upper, furnishes three branches, which supply the internal rectus, the inferior rectus, and the inferior oblique. The twigs to the internal and inferior recti enter these muscles on their deep or ocular surfaces. The branch to the inferior oblique is a long nerve which passes forwards between the inferior and external recti, and its twigs enter the inferior oblique

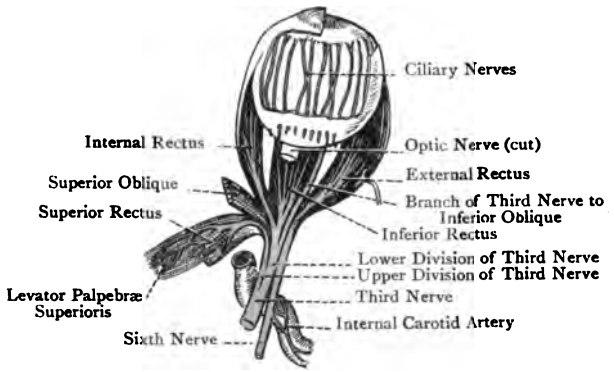

FIG. 451.—THE THIRD AND SIXTH CRANIAL NERVES IN THE ORBIT (HIRSCHFELD AND LEVEILLÉ).

muscle at its *posterior border*. Posteriorly it furnishes the *ganglionic branch*, which forms the short or motor root of the lenticular or ciliary ganglion.

The **fourth, trochlear,** or **pathetic nerve,** of small size, having left the wall of the cavernous sinus, enters the orbit through the sphenoidal fissure above the muscles, and internal to, but on a slightly higher plane than, the frontal nerve. Having passed inwards over the levator palpebræ superioris, it enters the posterior part of the superior oblique muscle on its *superficial* or *orbital surfa e*, this being the only muscle which it supplies.

The **sixth** or **abducent nerve,** having left the cavernous sinus, enters the orbit through the sphenoidal fissure, and passes between the two heads of the external rectus muscle. In this situation it has the lower division of the third nerve above it, and the ophthalmic veins below it. It supplies the external rectus, its twigs entering the muscle on its deep or ocular surface.

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Branches of the Ophthalmic Division of the Fifth Nerve.—The ophthalmic nerve, having left the outer wall of the cavernous sinus, and before arriving at the sphenoidal fissure, gives off the nasal nerve, and then divides into the frontal and lachrymal nerves.

The **frontal nerve,** of large size, enters the orbit through the sphenoidal fissure above the muscles. In this situation it has the lachrymal nerve external to, and on the same plane with, it, and the fourth nerve internal to it, but on a slightly higher plane. It then passes forwards on the upper surface of the levator palpebræ superioris, underneath the periosteum of the roof of the orbit, and before arriving at the supra-orbital margin it divides into two branches, supra-orbital and supratrochlear.

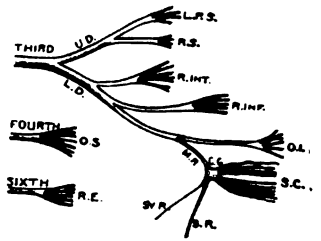

FIG. 452.—SCHEME OF THE DISTRIBUTION OF THE THIRD, FOURTH, AND SIXTH CRANIAL NERVES (FLOWER).

Third Nerve
- U.D. Upper Division
  - L.P.S. Levator Palpebræ Superioris
  - R.S. Rectus Superior
- L.D. Lower Division
  - R.Int. Rectus Internus
  - R.Inf. Rectus Inferior
  - O.I. Obliquus Inferior
- C.G. Ciliary Ganglion
- M.R. Motor Root

S.R. Sensory Root (from Nasal Nerve)
Sy.R. Sympathetic Root
S.C. Short Ciliary Nerves
Fourth Nerve—O.S. Obliquus Superior
Sixth Nerve—R.E. Rectus Externus

The *supra-orbital nerve*, which in size and direction is the continuation of the frontal, passes forwards to the supra-orbital notch, or foramen, through which it emerges in company with the supra-orbital artery. On the forehead it divides into two branches, outer and inner, which have been already described (see p. 992). Sometimes this division takes place within the orbit, and in these cases the inner branch emerges through the frontal notch.

The *supratrochlear nerve*, of small size, passes forwards and inwards to the trochlea or pulley of the superior oblique muscle, above which it emerges on to the forehead, where it has been previously described (see p. 992). Before leaving the orbit it gives off a small twig, which passes downwards, close to the pulley of the superior oblique, to form a loop with the infratrochlear branch of the nasal nerve.

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The **lachrymal nerve** enters the orbit through the sphenoidal fissure, above the muscles, and external to the frontal nerve. It then passes forwards and outwards along the upper border of the external rectus muscle, in company with the lachrymal artery. On reaching the lachrymal gland it furnishes numerous branches to its deep surface, and is then continued beneath it through the superior palpebral ligament, to be distributed to the skin and conjunctiva of the outer part of the upper eyelid, and the skin in the region of the external angular process of the frontal bone. Near the lachrymal gland it sends downwards a small twig, which joins the temporal branch of the orbital or temporo-malar nerve.

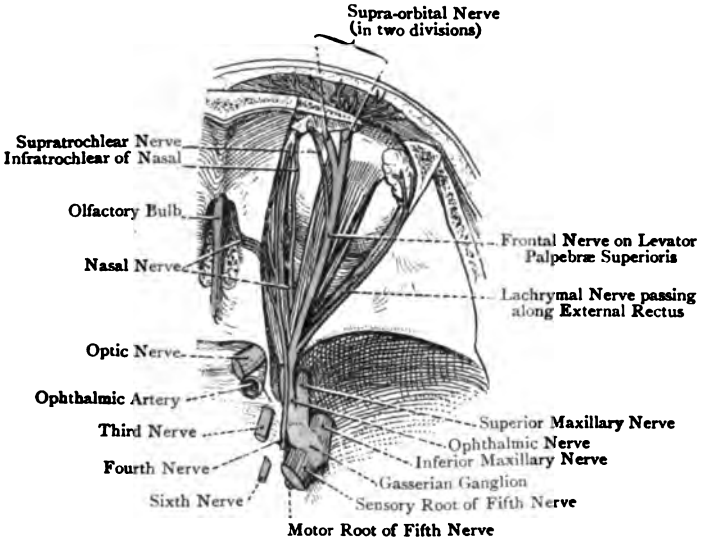

FIG. 453.—DISSECTION OF THE ORBIT FROM ABOVE (HIRSCHFELD AND LEVEILLÉ).

The **nasal nerve** is more deeply placed than the frontal and lachrymal. It enters the orbit through the sphenoidal fissure, and passes between the two heads of the external rectus muscle, lying between the upper and lower divisions of the third nerve. It then passes obliquely inwards and forwards to the inner wall of the orbit, lying beneath the superior rectus and above the optic nerve, and subsequently between the superior oblique and the internal rectus. Having reached the inner wall of the orbit at the anterior ethmoidal, or internal orbital, foramen it parts with its infratrochlear branch, and then passes through that foramen, in company with the anterior ethmoidal artery, and so enters the anterior fossa of the base of the skull. It then passes forwards and inwards in a groove on the upper surface of the cribriform plate of the ethmoid bone,

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lying under cover of the dura mater. Having reached the nasal slit at the side of the fore part of the crista galli, it descends through this slit into the nasal fossa, and immediately gives off a *septal branch*. Thereafter the nerve descends in a groove on the posterior surface of the nasal bone, furnishing offsets to the mucous membrane of the outer wall of the nasal fossa, in front of the superior and middle conchæ. Finally, the nerve emerges between the lower border of the nasal bone and the upper lateral nasal cartilage, and descends beneath the compressor naris muscle to supply the skin of the tip and lower part of the side of the nose.

In connection with this remarkable course of the nerve it is to be noted that it is to be met with in four different regions, namely, (1) in the orbit; (2) on the cribriform plate of the ethmoid bone in the anterior cranial fossa; (3) in the nasal fossa; and (4) on the face, in the region of the tip of the nose.

Branches.—The *ganglionic branch* forms the long or sensory root of the lenticular ganglion. It is slender, about ½ inch long, and arises from the nasal as it passes between the two heads of the external rectus. It enters the ciliary ganglion at its postero-superior angle.

The *long ciliary nerves*, usually two in number, arise from the nasal immediately after it has crossed the optic nerve, and they communicate with the short ciliary nerves from the ciliary ganglion, which they accompany to the back part of the sclerotic. Here they pierce the sclerotic, and are distributed along with the short ciliary nerves.

The *infratrochlear nerve* arises from the nasal close to the anterior ethmoidal foramen, and passes forwards beneath the superior oblique muscle. Near the pulley of that muscle it receives a twig from the supratrochlear nerve, and then, passing beneath the pulley, it emerges from the orbit at the inner canthus to be distributed to the skin and conjunctiva of the inner parts of the eyelids, the side of the root of the nose, the lachrymal sac, and the caruncula lacrimalis.

As the nerve traverses the anterior ethmoidal canal it furnishes twigs to the mucous membrane of the frontal air-sinus and of the anterior ethmoidal cells.

A *spheno-ethmoidal* or *posterior ethmoidal branch* is described as passing through the posterior ethmoidal canal to supply the mucous membrane of the posterior ethmoidal cells and of the sphenoidal air-sinus.

For the branches of the nasal nerve to the exterior of the nose and to the nasal fossa, see p. 1101 and 1179.

Ciliary, Lenticular, or **Ophthalmic Ganglion.**—This is a small quadrilateral body, about the size of a moderately large pin-head, which is situated in the posterior part of the orbit, where it lies flattened upon the outer side of the optic nerve. It is usually in close contact with that nerve, and is recognised by its reddish-pink colour. Posteriorly it receives its three roots, and anteriorly the

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short ciliary nerves pass forwards from it. The roots are called long, short, and middle. The **long** or **sensory root** is derived from the nasal nerve as it passes between the two heads of the external rectus. It is slender, about ½ inch long, and enters the postero-superior angle of the ganglion. The **short** or **motor root** is derived from the long branch of the lower division of the third nerve which supplies the inferior oblique muscle, and it enters the postero-inferior angle of the ganglion. The **middle** or **sympathetic root**

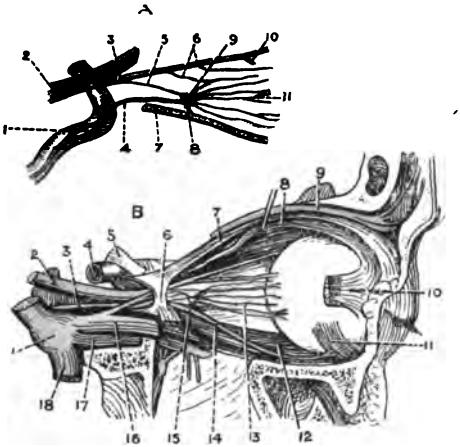

FIG. 454.—A, THE CILIARY GANGLION; B, THE NERVES OF THE ORBIT (EXTERNAL VIEW) (HIRSCHFELD AND LEVEILLÉ).

A

1. Cavernous Plexus
2. Ophthalmic Nerve
3. Nasal Nerve
4. Sympathetic Root of Ciliary Ganglion
5. Sensory Root of Ciliary Ganglion
6. Long Ciliary Nerves
7. Branch of Third Nerve to Inferior Oblique
8. Motor Root of Ciliary Ganglion
9. Ciliary Ganglion
10. Infratrochlear Branch of Nasal Nerve
11. Short Ciliary Nerves

B

1. Gasserian Ganglion
2. Third Nerve
3. Sixth Nerve
4. Internal Carotid Artery
5. Optic Nerve
6. Fibrous Ring for Recti
7. Levator Palpebræ Superioris
8. Superior Rectus
9. Frontal Nerve
10. External Rectus
11. Inferior Oblique
12. Inferior Rectus
13. Short Ciliary Nerves
14. Branch of Third Nerve to Inferior Oblique
15. Ciliary Ganglion
16. Ophthalmic Nerve
17. Superior Maxillary Nerve
18. Interior Maxillary Nerve

is a very minute nerve which is derived from the cavernous plexus of the sympathetic, and it usually reaches the ganglion in company with the long root. It may, however, join the ganglion separately, and then it does so in close proximity to the entrance of the long root.

The **branches** of the ciliary ganglion are called the *short ciliary nerves*. They are from six to eight in number, and come off, in two groups, from the antero-superior and antero-inferior angles. The

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nerves of the lower group usually exceed those of the upper in number. As they pass forward above and below the optic nerve they divide, and give rise to from sixteen to twenty delicate filaments. Having reached the back of the eyeball, they pierce the sclerotic around the entrance of the optic nerve. They then pass forwards between the sclerotic and the choroid, giving twigs to the latter, and they are finally distributed to the ciliary muscle, the iris, and the cornea. The short ciliary nerves thus convey to the eyeball sensory fibres from the ophthalmic division of the fifth nerve, motor fibres from the third nerve, and sympathetic fibres from the cavernous plexus of the sympathetic.

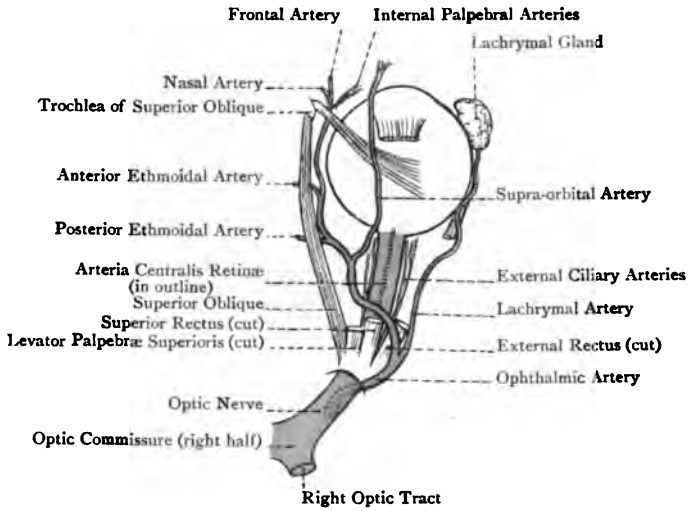

FIG. 455.—DISSECTION OF THE RIGHT ORBIT FROM ABOVE, SHOWING THE OPTIC NERVE, OPHTHALMIC ARTERY, AND SUPERIOR OBLIQUE MUSCLE.

Summary of the Ophthalmic Nerve.—This nerve is entirely sensory. It supplies (1) the skin of (*a*) the frontal region and top of the skull, (*b*) the upper eyelid, and (*c*) the root, tip, and lower part of the side of the nose; (2) the caruncula lacrimalis and lachrymal sac; (3) the mucous membrane of the nasal fossa, and the palpebral conjunctiva; (4) the eyeball; and (5) the lachrymal gland.

Summary of the Ciliary Ganglion.—The branches of this ganglion supply the cornea, iris, and ciliary muscle. The fibres which supply the **sphincter pupillæ** are derived from the *third* or *oculo-motor nerve*, through means of the motor root of the ganglion. The fibres which supply the **dilator pupillæ** are derived from the *sympathetic*, through means of the sympathetic root of the ganglion, which is derived from the cavernous sympathetic plexus.

Branch of the Superior Maxillary Division of the Fifth.—The **orbital** or **temporo-malar nerve**, of small size, arises from the superior maxillary in the spheno-maxillary fossa. It enters the orbit through the spheno-maxillary fissure, and soon divides into two

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branches, temporal and malar. The *temporal branch* ascends upon the outer wall of the orbit, and, having received a communicating twig from the lachrymal nerve, it leaves the cavity by passing through the temporal canal in the malar bone. Its destination is the skin of the anterior part of the temporal region.

The *malar branch* passes forwards in the angle between the outer wall and floor of the orbit, and leaves the cavity by passing through the malar canal, from which it subsequently emerges through the malar foramen. It is distributed to the skin over the malar bone.

Ophthalmic Artery.—This vessel arises from the internal carotid artery on the inner aspect of the anterior clinoid process, and it enters the orbit through the optic foramen, lying beneath the optic nerve. Within the orbit it is situated for a short distance on the outer side of the optic nerve, and then it passes obliquely inwards and forwards in a tortuous manner over the nerve to the inner wall of the orbit. Thereafter it passes forwards to the region of the internal angular process of the frontal bone, near which it divides into its two terminal branches, nasal and frontal.

Branches.—These are as follows :

1. Arteria centralis retinæ.
2. Posterior ciliary.
3. Lachrymal.
4. Muscular.
5. Supra-orbital.
6. Posterior ethmoidal.
7. Anterior ethmoidal.
8. Palpebral (two).
9. Nasal.
10. Frontal.

The **arteria centralis retinæ** arises from the ophthalmic at the back part of the orbit below the optic nerve. Its direction is forwards beneath the nerve, and, at a point about ½ inch behind the eyeball, it enters the nerve, and passes forwards in its centre to the retina, upon which it ramifies.

The **posterior ciliary arteries** arise from the ophthalmic whilst it is below the optic nerve. They are arranged in two sets, external and internal, which pass forwards on either side of the optic nerve to the back part of the eyeball. Here they pierce the sclerotic, and the majority of them enter the choroid coat under the name of the *short ciliary arteries*. Two of them, however, are fairly large, and are known as the *long ciliary arteries*. They pass forwards between the sclerotic and the choroid, one on each side, and are distributed to the ciliary muscle and iris.

The **lachrymal artery** arises from the ophthalmic on the outer side of the optic nerve, and passes forwards along the upper border of the external rectus muscle to the lachrymal gland. In its course it furnishes the following branches : (1) a recurrent meningeal branch, which passes through the outer part of the sphenoidal fissure to the middle cranial fossa, where it anastomoses with the middle meningeal artery ; (2) muscular and anterior ciliary branches, the latter piercing the sclerotic very near the corneal margin ;

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(3) temporal and malar offsets, which pass through the temporal and malar canals of the malar bone to the face and temporal region, in company with the temporal and malar branches of the temporo-malar or orbital nerve ; (4) two external palpebral arteries, superior and inferior, which pass inwards in the upper and lower eyelids, and anastomose with the internal palpebral branches of the ophthalmic, thus forming arterial arches ; and (5) glandular branches to the lachrymal gland.

The **muscular branches** arise from the ophthalmic in two sets, outer and inner, and also from some of its branches, *e.g.*, the lachrymal and supra-orbital. They furnish a few of the anterior ciliary arteries.

The **supra-orbital artery** arises from the ophthalmic as it crosses

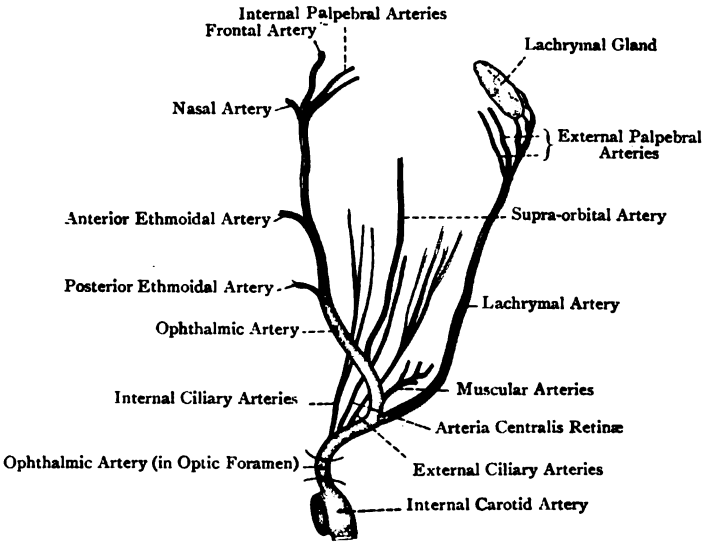

FIG. 456.—DIAGRAM OF THE OPHTHALMIC ARTERY AND ITS BRANCHES.

inwards over the optic nerve. It courses forwards to the supra-orbital notch, through which it passes, with the corresponding nerve, to the forehead. It supplies the upper eyelid and the frontal region, and anastomoses with the superficial temporal and frontal arteries.

The **posterior ethmoidal artery,** a small vessel, passes through the posterior ethmoidal canal on the inner wall of the orbit, and is distributed to the mucous membrane of the posterior ethmoidal cells, and the mucous membrane of the upper and back part of the outer wall of the nasal fossa. The latter branches pass through foramina in the cribriform plate.

The **anterior ethmoidal artery** is larger than the preceding. It

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passes through the anterior ethmoidal canal along with the nasal nerve, and enters the anterior fossa of the base of the skull. Here it crosses the cribriform plate of the ethmoid bone to the nasal slit by the side of the crista galli. It then descends through this slit, still in company with the nasal nerve, traverses the nasal groove on the posterior surface of the nasal bone, and finally emerges between the lower border of the nasal bone and the upper lateral nasal cartilage to the tip of the nose. Its branches supply the dura mater in the anterior cranial fossa, the mucous membrane of the anterior ethmoidal cells and corresponding frontal sinus, the mucous membrane of the upper and anterior parts of the nasal fossa, and the skin of the tip of the nose.

The **palpebral arteries** (internal) are two in number, superior and inferior, and are distributed to the eyelids. They arise, separately or conjointly, from the ophthalmic close to the pulley of the superior oblique muscle, and each takes an outward course in the corresponding eyelid. They anastomose with the superior and inferior palpebral branches of the lachrymal artery, thus forming arterial arches.

The **nasal artery** is one of the terminal branches of the ophthalmic. It emerges from the orbit above the internal tarsal ligament, and is distributed to the upper part of the side of the nose in the region of the root, where it anastomoses with the angular and lateral nasal branches of the facial artery.

The **frontal artery** is the other terminal branch of the ophthalmic. It emerges from the orbit at the inner angle, and then ascends to the frontal region, along with the supratrochlear nerve, to be distributed to the integument by the side of the median line. It anastomoses with the supra-orbital artery and its fellow of the opposite side.

Ophthalmic Veins.—These are two in number, superior and inferior. The **superior ophthalmic vein,** of large size, commences at the inner angle of the orbit, where it communicates freely with the angular vein, which is the commencement of the facial vein. It accompanies the ophthalmic artery, passing outwards and backwards over the optic nerve. Having reached the inner end of the sphenoidal fissure, the vessel passes between the two heads of the external rectus muscle, and through the fissure, after which it opens into the anterior part of the cavernous sinus. Its tributaries correspond for the most part to the branches of the ophthalmic artery. It does not, however, receive the frontal vein, nor the supra-orbital vein, but it is in communication with the latter by means of a small branch through the supra-orbital foramen. The **inferior ophthalmic vein** arises in connection with the lower posterior ciliary and lower muscular veins. It passes backwards along the floor of the orbit, and, as a rule, it joins the superior ophthalmic vein before that vessel passes between the two heads of the external rectus, thus giving rise to what is known as the **common ophthalmic vein.** It may, however, leave the orbit separately and open independently into the anterior part of the cavernous sinus. It com-

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municates freely with the pterygoid plexus of veins through the spheno-maxillary fissure, and that plexus sometimes represents its mode of termination.

Structures passing through the Sphenoidal Fissure.—These structures are as follows:

1. The third nerve.
2. The fourth nerve.
3. The nasal, lachrymal, and frontal nerves.
4. The sixth nerve.
5. The sympathetic root of the ciliary ganglion.
6. The two ophthalmic veins.
7. The orbital branch of the middle meningeal artery.
8. The recurrent branch of the lachrymal artery.
9. A process of the dura mater.

The lachrymal, frontal, and fourth nerves enter the orbit above the external rectus muscle, in the order named from without inwards.

The third nerve, the nasal nerve, and the sixth nerve enter the orbit between the two heads of the external rectus muscle, the third

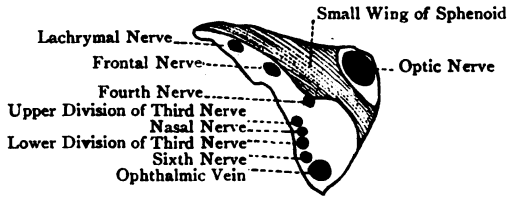

FIG. 457.—DIAGRAM OF THE LEFT SPHENOIDAL FISSURE, SHOWING THE TRANSMITTED STRUCTURES (POSTERIOR VIEW).

nerve having previously broken up into two divisions; and the two ophthalmic veins leave the orbit between the two heads of the external rectus. The order of parts between the two heads of the external rectus, from above downwards, is as follows:

1. The superior division of the third nerve.
2. The nasal nerve.
3. The inferior division of the third nerve.
4. The sixth nerve.
5. The ophthalmic veins (or vein).

The sympathetic root of the ciliary ganglion passes through the sphenoidal fissure independently, or along with the nasal nerve, or sometimes with the third nerve.

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THE FACE.

Landmarks.—The nasal eminence or glabella of the frontal bone can be felt just above the root of the nose, and extending outwards from it on either side is the superciliary ridge, behind the inner part of which is the corresponding frontal air-sinus. Below the superciliary ridge the supra-orbital arch can readily be felt, and at the junction of its inner third and outer two-thirds is the supra-orbital notch, or foramen, for the passage of the supra-orbital nerve and artery. A line drawn from the position of the supra-orbital notch to the base of the inferior maxilla, in such a manner as to pass between the lower bicuspid teeth, crosses in succession the infra-orbital and mental foramina. The infra-orbital foramen lies in this line at a point about ½ inch below the infra-orbital margin, and it indicates the exit of the infra-orbital nerve and artery from the infra-orbital canal. The mental foramen in the adult lies midway between the alveolar and basilar borders of the inferior maxilla, and it indicates the exit of the mental nerve and artery from the inferior dental canal.

In line with the tragus of the auricle the zygomatic arch can be felt, and leading backwards from it above the orifice of the meatus auditorius externus is the posterior root of the zygoma. This root is continued into the supramastoid crest, which corresponds to the level of the tegmen antri. In connection with the supramastoid crest it is important to note the position of the suprameatal triangle of Macewen. This triangle is bounded above by the supramastoid crest, below by the postero-superior part of the meatus auditorius externus, and behind by a vertical line connecting the upper and lower boundaries, this line being continuous with the posterior part of the meatus auditorius externus.

The superficial temporal artery and auriculo-temporal nerve lie directly in front of the tragus, the division of the artery into its anterior and posterior branches taking place about the level of the upper part of the auricle. The anterior branch of the artery lies nearly an inch above the external angular process of the frontal bone, and the posterior branch about an inch above the upper part of the auricle.

The parotid gland is situated in front of the auricle. It is limited above by the zygoma, behind by the auricle, and inferiorly it extends for a limited distance into the digastric triangle of the neck. Anteriorly it extends for a short distance over the masseter muscle, and Stensen's duct issues from its anterior border. The course of this duct may be indicated by a line drawn from the incisura intertragica, or from the junction of the lobule and cartilage of the auricle, to a point midway between the nostril and the red margin of the upper lip. About the middle third of this line corresponds to the duct. Above it is the transverse facial artery, and below it are the infra-orbital branches of the facial nerve. The course of the

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facial nerve through the parotid gland may be indicated by a line drawn forwards from the lobule of the auricle parallel to the line indicating the course of Stensen's duct.

The posterior border of the ramus of the inferior maxilla can readily be felt. It leads superiorly to the condyle and temporo-mandibular joint, and inferiorly to the angle of the bone. Extending forwards from the angle is the basilar border, which, about 2 inches from the angle, supports the facial artery, pulsation being readily felt, during life, in this part of the vessel, in front of the masseter muscle, the facial vein intervening between the two. In this situation a lymphatic gland lies in contact with the artery. From this point the facial artery extends, in a tortuous manner, to the inner canthus of the eye, passing close to the angle of the mouth, the facial vein pursuing a comparatively straight course.

In the median line of the face the structures to be noted are the nasal bones, nasal cartilages, dorsum and tip of the nose, alæ nasi, columella nasi, and the philtrum, which latter is the median groove leading from the columella nasi to the upper lip.

For the component parts of the auricle, see p. 1114.

The palpebræ or eyelids are to be noted, along with the palpebral fissure between them, and the canthi, outer and inner, at either extremity. The tarsal plates of the upper and lower eyelids can easily be felt, and connected with their inner extremities is the internal tarsal ligament, or tendo oculi. This latter may be made tense by approximating the eyelids, and drawing them outwards. It crosses the lachrymal sac a little above the centre. The eyelids being everted, the outlines of the Meibomian glands may be seen, these being arranged in a linear manner, and being placed perpendicular to the palpebral margins. The eyelashes, or cilia, on the margins of the eyelids are to be noted, and within these are the orifices of the ducts of the Meibomian glands, which are arranged in a row. Along the line of the eyelashes the skin of the eyelid becomes continuous with the palpebral conjunctiva, and along the line of reflection of the palpebral conjunctiva on to the eyeball the recess, known as the fornix, is to be noted. At the inner canthus, where the eyelids do not meet, there is a recess between the lids and the eyeball, which lodges a small red fleshy protuberance, called the caruncula lacrimalis, which is provided with a few delicate hairs. In this situation there is the fold called the plica semilunaris. Upon the eyelids at their inner ends the papillæ lacrimales are visible, and on each papilla is a minute orifice, called the punctum lacrimale. The lower papilla is larger than the upper, and is placed a little farther out. Each punctum leads into the lachrymal canal, and by these canals the tears are conveyed into the lachrymal sac, and thence by the nasal duct into the inferior meatus of the nose. The position of the lachrymal sac may be indicated by drawing the eyelids outwards, so as to render tense the tendo oculi, which, as stated, crosses the sac a little above its centre.

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Muscles of the Face.

Orbicularis Palpebrarum—Orbital Portion—*Origin.*—(1) The inner part of the internal tarsal ligament; (2) the outer surface of the nasal process of the superior maxilla; and (3) the internal angular process of the frontal bone.

Insertion.—This corresponds to the origin, there being no attachment to the outer part of the orbit.

Palpebral Portion—*Origin.*—The upper and lower surfaces of the internal tarsal ligament.

Insertion.—The upper and lower surfaces of the external tarsal ligament.

Nerve-supply.—The facial nerve.

Action—**Orbital Portion.**—(1) The upper half depresses the eyebrow, and antagonizes the frontalis muscle; (2) the lower half elevates the skin of the infra-orbital region. **Palpebral Portion.**—This closes the eyelids, as in winking, the upper lid being depressed and the lower raised, the former movement being more free than the latter. Through means of its connection with the internal tarsal ligament the palpebral portion draws forwards the front part of the lachrymal sac, and so contributes to the removal of the tears. When the entire muscle contracts the lids are forcibly closed, and drawn slightly inwards.

The upper part of the muscle is related by its deep surface to the frontalis, the supra-orbital vessels and nerve, and the supratrochlear nerve. The chief deep relations of the lower part are the levator labii superioris, and, beneath that, the infra-orbital nerve.

Internal Tarsal Ligament.—This is also called the *tendo oculi*, or *tendo palpebrarum.* It is attached internally to the outer surface of the nasal process of the superior maxilla, immediately in front of the lachrymal groove. Its direction is outwards in front of the lachrymal sac, and it bifurcates at the inner canthus, the divisions diverging, and taking attachment to the inner extremities of the tarsal plates. As the ligament passes in front of the lachrymal sac it is in intimate contact with that sac, and it gives origin to the palpebral portion of the orbicularis palpebrarum, which explains the action of that portion of the muscle upon the lachrymal sac.

External Tarsal Ligament.—This is attached externally to the frontal process of the malar bone. Its direction is inwards, and it bifurcates at the outer canthus, the divisions taking attachment to the outer extremities of the tarsal plates.

Tensor Tarsi (*Muscle of Horner*)—*Origin.*—The crest of the lachrymal bone, behind the lachrymal sac.

Insertion.—By means of two slips into the inner extremities of the tarsal plates, where the fibres become continuous with the ciliary fibres of the orbicularis palpebrarum.

Nerve-supply.—The facial nerve.

The direction of the muscle is outwards and forwards, and its two slips pass behind the lachrymal canals.

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Action.—To draw backwards the outer part of the internal tarsal ligament, and in this manner compress the lachrymal sac, the effect of which is to propel the tears into the nasal duct.

Corrugator Supercilii—*Orig'n.*—The inner extremity of the superciliary ridge of the frontal bone.

Insertion.—The deep surface of the skin of the eyebrow at the centre.

Nerve-supply.—The facial nerve.

The direction of the muscle is outwards and upwards, and to reach the skin the fibres pass through the upper part of the orbicularis palpebrarum and the adjacent portion of the frontalis.

Action.—To draw the skin of the eyebrow inwards and downwards, giving rise to vertical wrinkles between the eyebrows, as in frowning.

The muscle is under cover of the inner portion of the upper half of the orbicularis palpebrarum, and it conceals the supratrochlear nerve as it emerges from the orbit.

Muscles of the Nose—Pyramidalis Nasi—*Origin.*—The aponeurosis of the compressor naris over the lower part of the nasal bone.

Insertion.—The deep surface of the skin over the glabella of the frontal bone. Some of the fibres become continuous with the mesial portion of the frontalis.

Nerve-supply.—The facial nerve.

Action.—To draw downwards the skin between the eyebrows, giving rise to transverse wrinkles.

Compressor Naris—*Origin.*—The superior maxilla between the canine fossa and the nasal notch.

Insertion.—By means of an expanded aponeurosis which blends with its fellow of the opposite side over the cartilaginous portion of the nose, and gives origin superiorly to the pyramidalis nasi.

Nerve-supply.—The facial nerve.

Action.—To depress the cartilaginous portion of the nose.

The muscle is triangular, and at its origin is under cover of the levator labii superioris alæque nasi.

Levator Labii Superioris Alæque Nasi — *Origin.* — The outer surface of the nasal process of the superior maxilla by a pointed extremity.

Insertion.—By means of two slips. The **inner** or **nasal slip** is inserted into the skin of the ala of the nose. The **outer** or **labial slip** is inserted into the skin of the upper lip, some of its fibres blending with the levator labii superioris, and others with the upper part of the orbicularis oris.

Nerve-supply.—The facial nerve.

Action.—(1) To raise the upper lip, and (2) to raise, and dilate, the ala of the nose.

The muscle is triangular, and covers the origin of the compressor naris.

Depressor Alæ Nasi—*Origin.*—The incisor fossa of the superior maxilla.

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Insertion.—The posterior part of the ala, and the adjacent part of the septum, of the nose.

Nerve-supply.—The facial nerve.

Action.—To depress the ala of the nose.

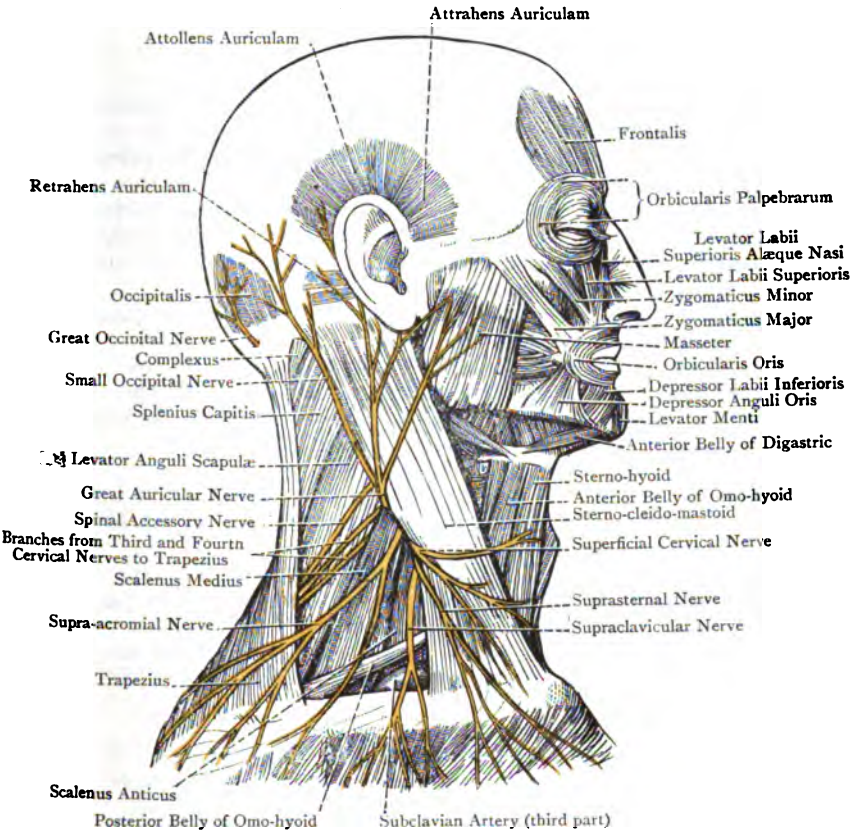

FIG. 458.—THE RIGHT SIDE OF THE HEAD AND NECK.

(The Platysma Myoides has been removed, and the Nerves are shown).

Dilator Naris Anterior—*Origin.*—The cartilage of the aperture of the nose.

Insertion.—The deep surface of the skin over the ala of the nose.

Nerve-supply.—The facial nerve.

Action.—To dilate the nostril.

Dilator Naris Posterior—*Origin.*—(1) The margin of the nasal notch of the superior maxilla; and (2) the accessory or sesamoid cartilages of the nose.

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Insertion.—The skin over the back part of the ala of the nose.

Nerve-supply.—The facial nerve.

Action.—To dilate the nostril.

Levator Labii Superioris—*Origin.*—The superior maxilla between the infra-orbital foramen and the lower margin of the orbit.

Insertion.—The skin of the upper lip.

Nerve-supply.—The facial nerve.

Action.—To raise the upper lip.

The muscle is quadrilateral. At its origin it is overlapped by the lower half of the orbicularis palpebrarum, and it covers the infra-orbital nerve and artery as they emerge from the infra-orbital foramen. At its insertion the fibres interlace with those of the upper half of the orbicularis oris. Its inner border is joined by some of the fibres of the outer or labial slip of the levator labii superioris alæque nasi, and its outer border is joined by some fibres of the zygomaticus minor.

Levator Anguli Oris—*Origin.*—The upper part of the canine fossa of the superior maxilla, under cover of the levator labii superioris.

Insertion.—The angle of the mouth, where some of the fibres are inserted into the skin, whilst others decussate with those of the depressor anguli oris, and enter the lower lip, mingling with those of the lower half of the orbicularis oris.

Nerve-supply.—The facial nerve.

The direction of the muscle is downwards and slightly outwards.

Action.—To raise the angle of the mouth, and at the same time to draw it slightly inwards.

The infra-orbital nerve and artery are superficial to the muscle.

Zygomaticus Minor—*Origin.*—The anterior and lower part of the malar bone, close to the superior maxilla.

Insertion.—The skin of the upper lip immediately external to the levator labii superioris, with the outer border of which muscle some of its fibres blend.

Nerve-supply.—The facial nerve.

The muscle is directed downwards and inwards.

Action.—To raise feebly the upper lip, and at the same time to draw it slightly outwards.

Zygomaticus Major—*Origin.*—The outer surface of the malar bone near the zygomatic suture.

Insertion.—The skin at the angle of the mouth, where its fibres blend with those of the orbicularis oris.

Nerve-supply.—The facial nerve.

The muscle is directed downwards and inwards.

Action.—To draw the angle of the mouth upwards and outwards.

Risorius of Santorini—*Origin.*—The deep fascia which covers the masseter muscle and parotid gland.

Insertion.—The skin at the angle of the mouth, where its fibres blend with the orbicularis oris.

Nerve-supply.—The facial nerve.

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The direction of the muscle is inwards, some of its fasciculi also ascending.

Action.—To draw the angle of the mouth outwards and slightly downwards. It is not a muscle of laughter, but is expressive of scorn or pain.

The muscle consists of a few scattered fasciculi, which are embedded in the adipose tissue over the buccinator, and it is to be regarded as a detached portion of the platysma myoides.

Buccinator—*Origin.*—(1) The outer surfaces of the alveolar borders of the superior and inferior maxillæ, opposite the three molar alveoli; and (2) the anterior aspect of the pterygo-mandibular ligament.

Insertion.—The orbicularis oris at the angle of the mouth.

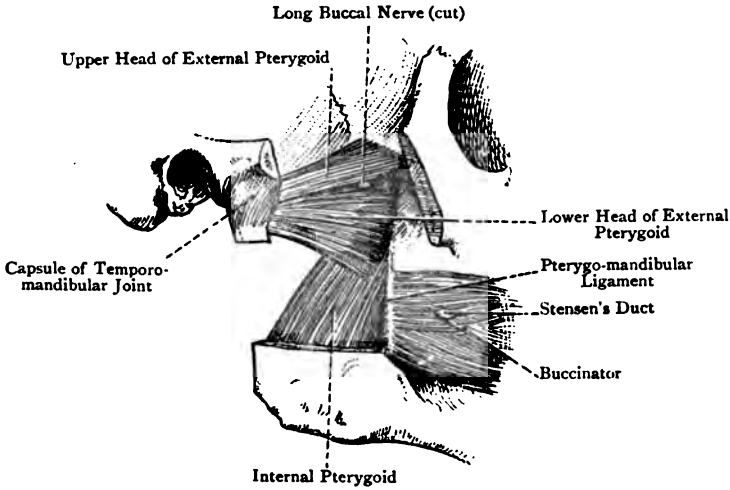

FIG. 459.—THE PTERYGOID AND BUCCINATOR MUSCLES.

The central fibres decussate, those from above entering the lower lip, and those from below entering the upper lip. The highest and lowest fibres take no part in this decussation, the highest passing directly into the upper lip, and the lowest into the lower lip.

Nerve-supply.—The short buccal nerves, which are derived from (1) the infra-orbital branches of the temporo-facial division of the facial, and (2) the buccal branches of the cervico-facial division of the facial, nerve.

Action.—(1) To draw the angle of the mouth outwards, and press the lips against the teeth, thus preventing the food from accumulating between the lips and the teeth during mastication; and (2) to regulate the expulsion of air from the buccal cavity when the buccal aperture is narrowed, as in playing the flute, or in whistling.

The muscle is expanded over the cheek, but towards the angle

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of the mouth it becomes narrow and thick. It is pierced by Stensen's duct opposite the second upper molar tooth, and the long buccal nerve also passes through it on its way to the mucous membrane of the cheek. Externally the muscle is overlapped by the anterior border of the masseter, from which it is separated by the buccal pad of fat.

Buccal Pad of Fat.—This is a well-defined collection of fat which is situated upon the buccinator muscle close to the anterior border of the masseter. It is continuous with the fat of the zygomatic fossa, and is well developed in young children.

Depressor Anguli Oris (*triangularis menti*)—*Origin.*—The external oblique line of the inferior maxilla, from about the level of the canine alveolus to about the level of the first molar alveolus.

Insertion.—The angle of the mouth, where some of the fibres are attached to the skin, whilst others decussate with those of the levator anguli oris and enter the upper lip, in which they mingle with the upper part of the orbicularis oris.

Nerve-supply.—The facial nerve.

Action.—To depress the angle of the mouth.

Internally the muscle overlaps a portion of the depressor labii inferioris.

Depressor Labii Inferioris (*quadratus menti*)—*Origin.*—The lower part of the outer surface of the body of the inferior maxilla, commencing almost close to the symphysis, and extending outwards to a point just below the mental foramen.

Insertion.—The skin of the lower lip.

Nerve-supply.—The facial nerve.

The muscle is directed upwards and inwards.

Action.—To draw the lower lip downwards and slightly outwards.

The muscle is overlapped externally by a portion of the depressor anguli oris, and internally it is in contact superiorly with its fellow of the opposite side. The deep surface is related externally to the mental foramen and the mental nerve and vessels, and internally to part of the levator menti. In the lower lip its fibres pass amongst those of the lower part of the orbicularis oris.

Levator Menti, or **Levator Labii Inferioris**—*Origin.*—The incisor fossa of the inferior maxilla.

Insertion.—The skin of the chin.

Nerve-supply.—The facial nerve.

The muscle is directed downwards and forwards.

Action.—(1) To raise the integument of the chin ; and (2) to elevate and protrude the lower lip. It gives rise to a proud or imperious expression, and has been hence called the *musculus superbus.*

Superiorly the muscle is under cover of the depressor labii inferioris. Inferiorly it appears along with its fellow, between the two depressor labii inferioris muscles.

Orbicularis Oris.—This is a complex muscle, being composed of three strata. The *superficial stratum* consists of fibres which are prolonged from the elevators and depressors of the angles of the

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mouth, and extend as far as the centre of the lip, but are not continuous with those of the opposite half. They are *inserted* into the skin, and are partially reinforced by fibres from the elevators of the upper lip, the zygomatic muscles, the risorius, the posterior fibres of the platysma myoides, and the dépressor labii inferioris.

The *intermediate stratum* consists of fibres which are derived from the buccinator muscles. These fibres are disposed transversely, and those of opposite sides are directly continuous. The fibres of this stratum extend quite to the margins of the lips.

The foregoing fibres are destitute of bony and cartilaginous attachments.

The *deepest stratum* consists of fibres which are so disposed as to constitute specially-named muscles. These are four in number for the upper lip, two for each half, namely, the musculus incisivus superior and the musculus naso-labialis ; and two for the lower lip, one for each half, namely, the musculus incisivus inferior.

The **musculus incisivus superior** arises from the incisor fossa of the superior maxilla, and turns outwards in the upper lip towards the angle of the mouth, where the fibres blend with the orbicularis oris. The **musculus naso-labialis** arises from the back part of the nasal septum, and, like the preceding, turns outwards in the upper lip to blend with the orbicularis oris. The **musculus incisivus inferior** arises from the incisor fossa of the inferior maxilla, and turns outwards in the lower lip towards the angle of the mouth, where the fibres blend with the orbicularis oris. In addition to the foregoing fibres there are oblique fibres which extend between the skin and the mucous membrane.

Nerve-supply.—The facial nerve.

Action.—(1) To close the oral aperture ; and (2) to press the lips against the alveolar margins.

The muscle is not a sphincter muscle, properly so called, inasmuch as the upper and lower fibres are not directly continuous at the angles of the mouth. It is separated from the buccal mucous membrane by the coronary arteries and the labial mucous glands.

The **labial mucous glands,** which are racemose, or acino-tubular, are numerous, and each is about the size of a small pea. They are situated on the deep surface of the mucous membrane of the lips, where they lie in the loose areolar tissue between the mucous membrane and the orbicularis oris. Their ducts open into the vestibule of the mouth.

The **buccal mucous glands,** also racemose, or acino-tubular, are situated between the mucous membrane of the cheek and the buccinator.

The **molar mucous glands,** also racemose, or acino-tubular, lie upon the buccinator in the vicinity of the terminal part of Stensen's duct. They are four or five in number, and their ducts, having pierced the buccinator, open into the vestibule of the mouth opposite the molar teeth.

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Nerves of the Face.

The nerves of the face are thirteen in number on either side. Twelve of these are sensory nerves, and one is motor, namely, the facial nerve.

The **facial** or **seventh cranial nerve** (*portio dura*) will only be described here after its emergence from the aqueduct of Fallopius in the petrous part of the temporal bone. It emerges from that

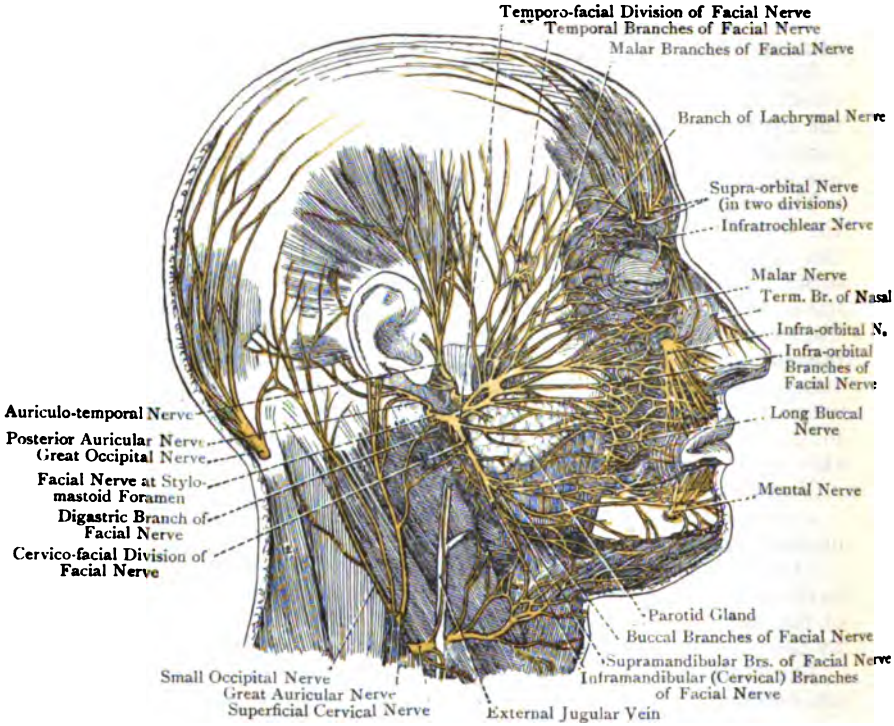

FIG. 460.—SUPERFICIAL DISSECTION OF THE RIGHT SIDE OF THE HEAD AND UPPER PART OF THE NECK (HIRSCHFELD AND LEVEILLÉ).

1, Sterno-cleido-mastoid ; 2, Trapezius.

aqueduct through the stylo-mastoid foramen, after which it passes downwards and then forwards into the parotid gland. Near the posterior border of the ramus of the inferior maxilla it breaks up into two terminal parts, called the temporo-facial and cervico-facial divisions.

Branches.—These are as follows : the posterior auricular, digastric, stylo-hyoid, and the two terminal divisions, namely, temporo-facial, and cervico-facial.

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The **posterior auricular nerve** arises from the facial close to the stylo-mastoid foramen. It ascends between the auricle and the mastoid process, where it lies deeply, and divides into two branches, auricular and occipital. The *auricular branch* passes upwards behind the auricle and beneath the retrahens auriculam, to be distributed to that muscle, and it may be to the attollens auriculam, as well as to the small intrinsic muscles on the inner aspect of the auricle. The *occipital branch* passes backwards to supply the occipitalis muscle. The posterior auricular nerve communicates with the great auricular, the small occipital, and the auricular branch (Arnold's nerve) of the pneumogastric.

The **digastric nerve** is directed downwards, and breaks up into branches which enter the posterior belly of the digastric muscle. One of the digastric branches communicates with the glosso-pharyngeal nerve.

The **stylo-hyoid nerve** usually arises in common with the preceding. It is of some length, and, passing forwards, it enters the stylo-hyoid muscle about its centre.

The **terminal divisions,** as stated, are called **temporo-facial** and **cervico-facial.** Both divisions continue to pass forwards in the parotid gland, crossing superficially the temporo-maxillary vein and the external carotid artery, the direction of these vessels being vertical. In this part of their course these divisions receive the following branches; the temporo-facial division receives two branches from the auriculo-temporal nerve, and the cervico-facial division receives branches from the great auricular nerve. The temporo-facial division, which is the larger of the two, traverses the upper part of the parotid gland, and the cervico-facial division passes through the gland in a forward and downward direction. Each division breaks up, within the gland, into three branches, and, as these pass in various directions over the face and upper portion of the neck, they ramify freely. The branches frequently communicate with each other in a plexiform manner, both in the parotid gland and on the face, the plexus thus formed being known as the *pes anserinus* or goose's foot. The ramifications also communicate with the branches of the three divisions of the fifth nerve which appear on the face, these being sensory nerves.

The **temporo-facial division** furnishes three sets of branches, namely, temporal, malar, and infra-orbital. The *temporal branches* ascend over the zygomatic arch to the temporal region, and are distributed to the following muscles: the attrahens and attollens auriculam, the intrinsic muscles on the outer surface of the auricle, the frontalis, the upper part of the orbicularis palpebrarum, and the corrugator supercilii. The temporal branches communicate with the supra-orbital and lachrymal branches of the ophthalmic, the temporal branch of the orbital from the superior maxillary, and the auriculo-temporal of the inferior maxillary, all of these being sensory nerves.

The *malar branches* pass forwards over the malar bone towards

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the outer angle of the orbit, and supply the outer part of the orbicularis palpebrarum. They form communications with the lachrymal branch of the ophthalmic, with the malar of the orbital, and with the infra-orbital, both these latter being branches of the superior maxillary, and all of them being sensory nerves.

The *infra-orbital branches*, the largest of this group, pass forwards to the region between the lower margin of the orbit and the upper lip. They supply the lower part of the orbicularis palpebrarum,

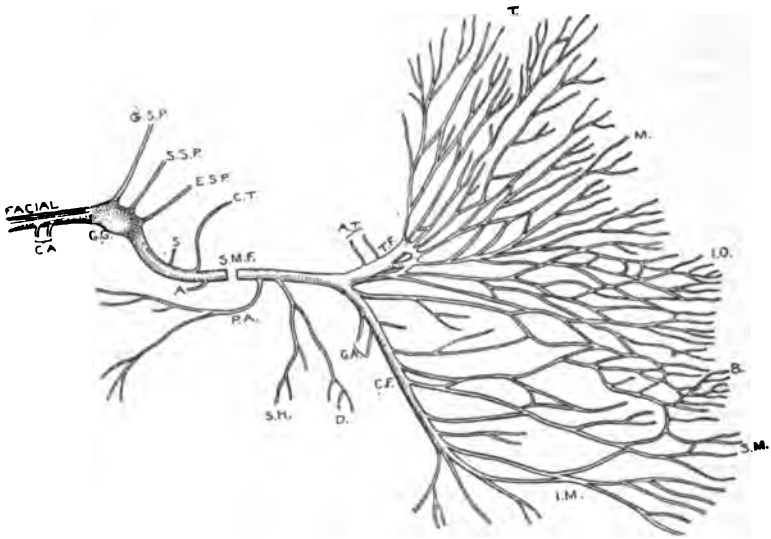

FIG. 461.—SCHEME OF THE FACIAL NERVE (FLOWER).

C.A. Communicating Twigs with Auditory
G.G. Geniculate Ganglion
G.S.P. Great Superficial Petrosal
S.S.P. Branch to Small Superficial Petrosal
E.S.P. External Superficial Petrosal
S. Branch to Stapedius Muscle
C.T. Chorda Tympani
A. Auricular Branch (Arnold's Nerve)
S.M.F. Stylo-mastoid Foramen
P.A. Posterior Auricular
S.H. Branch to Stylo-hyoid Muscle
D. Branch to Posterior Belly of Digastric
A.T. Communicating Branches from Auriculo-temporal
T.F. Temporo-facial Division
T. Temporal Branches
M. Malar Branches
I.O. Infra-orbital Branches
G.A. Communicating Branches from Great Auricular
C.F. Cervico-facial Division
B. Buccal Branches
S.M. Supramandibular Branches
I.M. Inframandibular Branches

the muscles of the nose, the elevators of the upper lip, the upper part of the orbicularis oris, and the buccinator. They communicate with the following sensory nerves: the infra-orbital of the superior maxillary, the infratrochlear of the nasal, and the terminal cutaneous branch of the nasal, from the ophthalmic. The communications with the infra-orbital nerve take place under cover of the levator labii superioris muscle, and form a somewhat intricate plexus, called the *infra-orbital plexus*.

The **cervico-facial division** likewise furnishes three sets of

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branches, namely, buccal, supramandibular, and inframandibular or cervical.

The *buccal branches* pass forwards over part of the masseter and the buccinator muscles to the angle of the mouth. They supply the buccinator and the outer part of the orbicularis oris, and are connected with the infra-orbital branches of the temporo-facial division, and with the *long buccal nerve*, which is a branch of the inferior maxillary division of the fifth nerve. The latter communications take the form of a plexus situated on the superficial surface of the buccinator muscle, called the *buccal plexus*.

The *supramandibular branches* pass forwards over the mandible to the region below the lower lip. They supply the lower part of the orbicularis oris, depressor anguli oris, depressor labii inferioris,

FIG. 462.—DIAGRAM OF THE SENSORY NERVES OF THE RIGHT SIDE OF THE HEAD.

1. Supra-orbital
2. Supratrochlear
3. Infratrochlear
4. Nasal
5. Lachrymal
6. Temporal of Orbital
7. Malar of Orbital
8. Infra-orbital
9. Auriculo-temporal
10. Long Buccal
11. Mental
12. Great Auricular
13. Small Occipital
14. Great Occipital

and levator menti muscles. They communicate with the mental branch of the inferior dental from the inferior maxillary nerve, under cover of the depressor anguli oris.

The *inframandibular* or *cervical branch* descends beneath the upper part of the platysma myoides and the deep cervical fascia to the suprahyoid region. Having pierced the deep fascia, it divides into branches which curve forwards and supply the platysma on its deep surface. It communicates freely with the upper branch of the superficial cervical nerve from the cervical plexus.

Summary of the Facial Nerve.—The facial nerve, after its emergence from the aqueduct of Fallopius through the stylo-mastoid foramen, supplies the following muscles: (1) the extrinsic and intrinsic muscles of the auricle; (2) the posterior belly of the digastric and the stylo-hyoid; (3) the muscles of the scalp, namely, the occipitalis and the frontalis; (4) the superficial

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muscles of the face, including the buccinator, but not the masseter, nor the levator palpebræ superioris; and (5) the platysma myoides. All these muscles, except the posterior belly of the digastric and the stylo-hyoid, are spoken of as muscles of expression. The nerve establishes free communications with all three divisions of the fifth nerve, which are sensory. It also communicates with the small occipital, great auricular, and superficial cervical, which are branches of the cervical plexus.

Sensory Nerves of the Face.—These, as stated, are twelve in number on either side. With one exception they are derived from the fifth cranial (trigeminal or trifacial) nerve, the exception being in the case of the great auricular, which is a branch of the cervical plexus. Most of them reach their distribution as independent nerves, but some sensory fibres reach the skin of the face through their connection with the branches of the facial nerve, as, for example, in the case of the auriculo-temporal and great auricular nerves. The sensory nerves are as follows:

A. Branches of the Fifth Cranial Nerve.

Distal Sources.	Proximate Sources.	Nerves.
1. Ophthalmic nerve.	(*a*) Frontal division.	Supra-orbital.
		Supratrochlear.
	(*b*) Lachrymal division.	Superior palpebral.
	(*c*) Nasal division.	Infratrochlear.
		External terminal branch of nasal.
2. Superior maxillary nerve.	(*a*) Superior maxillary.	Infra-orbital.
	(*b*) Orbital, or Temporo-malar.	Temporal.
		Malar.
3. Inferior maxillary nerve.	(*a*) Anterior division.	Long buccal.
	(*b*) Posterior division.	Auriculo-temporal.
	(*c*) Inferior dental of posterior division.	Mental.

B. Facial Branches of the Great Auricular Nerve.

Branches of the Fifth Cranial Nerve.—The **supra-orbital** and **supratrochlear nerves** have been already described (see p. 992). The former is distributed to the skin of the frontal region and the upper part of the scalp; and the latter to the skin of the lower and central portion of the frontal region. Both these nerves furnish twigs to the skin of the upper eyelid.

The **superior palpebral branch of the lachrymal nerve** pierces the superior palpebral ligament, and is distributed to the skin and conjunctiva of the outer part of the upper eyelid, as well as to the skin in the immediate vicinity of the external angular process of the frontal bone.

The **infratrochlear branch of the nasal nerve** emerges from the orbit below the pulley of the superior oblique muscle, and furnishes twigs to the skin and conjunctiva of the inner parts of the eyelids,

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the side of the root of the nose, the lachrymal sac, and the caruncula lacrimalis.

The **external terminal branch of the nasal nerve** emerges between the lower border of the nasal bone and the upper lateral nasal cartilage, and descends beneath the compressor naris muscle to the tip of the nose. Its twigs supply the skin of the tip, and lower part of the side, of the nose.

The **infra-orbital nerve** is the terminal part of the superior maxillary division of the fifth. It emerges from the infra-orbital canal through the infra-orbital foramen, where it is under cover of the levator labii superioris. In this situation it communicates with the infra-orbital branches of the facial, forming the *infra-orbital plexus*, and it divides into three sets of branches, namely, inferior palpebral, lateral nasal, and superior labial. The *inferior palpebral branches* ascend to supply the skin and conjunctiva of the lower eyelid. The *nasal branches* pass inwards, and are distributed to the skin of the side of the nose. The *superior labial branches*, long and large, descend to supply the skin and mucous membrane of one half of the upper lip. As they descend they furnish twigs to the skin between the infra-orbital foramen and the upper lip.

The **temporal branch of the orbital or temporo-malar** nerve is of small size. Having traversed the temporal canal in the malar bone, it pierces the temporal fascia about 1 inch above the front part of the zygoma, and behind the marginal process on the postero-superior or temporal border of the malar bone, and is distributed to a limited portion of the skin over the anterior part of the temporal region.

The **malar branch of the orbital** or **temporo-malar nerve** is of small size, and emerges from the malar canal in the malar bone through the malar foramen. It is distributed to the skin over the malar bone.

The **long buccal nerve** is a branch of the anterior division of the inferior maxillary nerve. It emerges from beneath the anterior border of the masseter on to the superficial surface of the buccinator, where it divides into branches which communicate freely with the buccal branches of the facial nerve, forming the *buccal plexus*. Its final distribution is to the skin and mucous membrane of the cheek, the branches to the latter piercing the buccinator.

The **auriculo-temporal nerve,** which is a branch of the posterior division of the inferior maxillary nerve, has been already described as regards its cutaneous distribution (see p. 995).

The **mental nerve** is one of the terminal branches of the inferior dental, which, in turn, is a branch of the posterior division of the inferior maxillary nerve. It emerges from the dental canal in the inferior maxilla through the mental foramen, under cover of the depressor anguli oris, and in line with the interval between the two lower bicuspid alveoli. Its branches supply the skin and mucous membrane of one half of the lower lip, and the skin over one half of the body of the inferior maxilla.

The supra-orbital, infra-orbital, and mental nerves, being fre-

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quently the seat of neuralgia, their positions for purposes of operative treatment can readily be ascertained in the following manner: A line drawn upwards from the position of the mental foramen, which is in line with the interval between the two lower bicuspid alveoli, to the supra-orbital notch, which is situated at the junction of the outer two-thirds and the inner third of the supra-orbital arch, will coincide with the infra-orbital foramen. This line, therefore, is over the points of emergence of these three important sensory nerves.

Branches of the Great Auricular Nerve.—The facial branches of the great auricular nerve, which is a branch of the cervical plexus, are distributed to the skin over the parotid gland. They send twigs into the gland which communicate with the cervico-facial division of the facial nerve.

Arteries of the Face.

The arteries of the face are as follows:

Sources.	Arteries.	Sources.	Arteries.
External carotid.	Facial.	Superficial temporal.	Transverse facial. Anterior temporal. Orbital.
Ophthalmic, from internal carotid.	Nasal. Frontal. Supra-orbital. Internal palpebral (superior and inferior). Terminal branch of anterior ethmoidal.	Internal maxillary.	Infra-orbital. Buccal.
		Inferior dental, from internal maxillary.	Mental.
Lachrymal, from ophthalmic.	External palpebral (superior and inferior). Temporal. Malar.		

The chief of these arteries are the facial and the transverse facial.

Facial Artery.—The facial artery (*external maxillary*) is one of the three anterior branches of the external carotid, being the highest in order. It is situated at first in the upper portion of the anterior triangle of the neck, where it has been previously described (see p. 1044). It leaves the neck and enters upon its facial course by mounting over the base and body of the inferior maxilla, in front of the anterior border of the masseter, where it is very superficial, being covered only by the platysma myoides and the integument. From this point it extends to the inner canthus of the eye, where it pierces the levator labii superioris alæque nasi, or becomes embedded in it, and terminates in its angular branch. Its course is upwards and forwards, and it describes many bends, being remarkable for its tortuosity, this being in adaptation to the great mobility of the surrounding parts. Though embedded in the fat, and covered by certain muscles, the facial part of the vessel is in no sense deeply placed.

Relations—*Superficial.*—The integument and platysma myoides, the risorius, the zygomatic muscles, and branches of the facial

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nerve. Its relation to the levator labii superioris is variable. It may be under cover of, or over, that muscle. *Deep.*—The body of the inferior maxilla (where pulsation can readily be felt in the vessel), the buccinator, the levator anguli oris, and the infra-orbital nerve. *External.*—The facial vein, which is at a little distance from it, except at the body and base of the mandible, where the vein lies close to the outer side of the vessel.

Facial Branches.—(1) *Muscular branches*, of small size, arise from the outer side of the vessel, and are distributed to the structures in the masseteric, buccal, and infra-orbital regions, where they anastomose with the buccal, transverse facial, and infra-orbital arteries. (2) The *inferior labial artery* passes forwards over the body of the mandible, and beneath the depressor anguli oris, to supply the structures between the lower lip and the base of the mandible. It anastomoses with the inferior coronary, mental, and submental arteries. (3) The *inferior coronary artery* arises just below the angle of the mouth, and passes inwards beneath the depressor anguli oris. In the lower lip it lies near the margin, between the orbicularis oris and the mucous membrane, and it anastomoses with its fellow of the opposite side, and with the inferior labial. (4) The *superior coronary artery*, of larger size than the inferior, arises just above the angle of the mouth, under cover of the zygomaticus major. Its position in the upper lip is similar to that of the inferior coronary in the lower lip, and it anastomoses with its fellow of the opposite side. Near the middle line it furnishes the *artery of the septum nasi*, which ramifies on the columella nasi as far as the tip of the nose. The superior and inferior coronary arteries of each side sometimes arise together. The vessels of each side, superior and inferior, form in each lip a tortuous arterial arch, which is necessarily divided in operations upon one or other lip. (5) The *lateral nasal arteries* arise opposite the nose, upon the side of which they ramify. They anastomose with the nasal branch of the ophthalmic, the artery of the septum, the terminal branch of the anterior ethmoidal artery, and its fellow of the opposite side. (6) The *angular artery* is the terminal branch of the facial at the inner canthus of the eye. It lies either beneath, or embedded in, the levator labii superioris alæque nasi, and supplies the side of the root of the nose and the adjacent part of the orbicularis palpebrarum. It anastomoses with the nasal branch of the ophthalmic artery.

The **facial vein** commences above the inner canthus of the eye in the *angular vein*, which is formed by the union of the frontal and supra-orbital veins. The course of the vessel is downwards and outwards, external to the artery and at a little distance from it, except over the body and base of the inferior maxilla, where it lies close to its outer side and in contact with the anterior border of the masseter. The vein is much less tortuous than the artery, and in the lower part of its course descends almost vertically. The cervical part of the vein, which terminates in the internal jugular, has been already described. The muscular

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relations of the vein correspond pretty much with those of the artery.

Its **tributaries** are as follows: (1) the frontal vein; (2) the supra-orbital vein, which communicates with the ophthalmic vein; (3 the angular vein, which receives internally the lateral na al veins, and externally a few superior palpebral veins, whilst posteriorly it communicates with the commencement of the superior ophthalmic vein, and internally with its fellow of the opposite side by means of the ***transverse nasal vein***, which lies over the bridge of

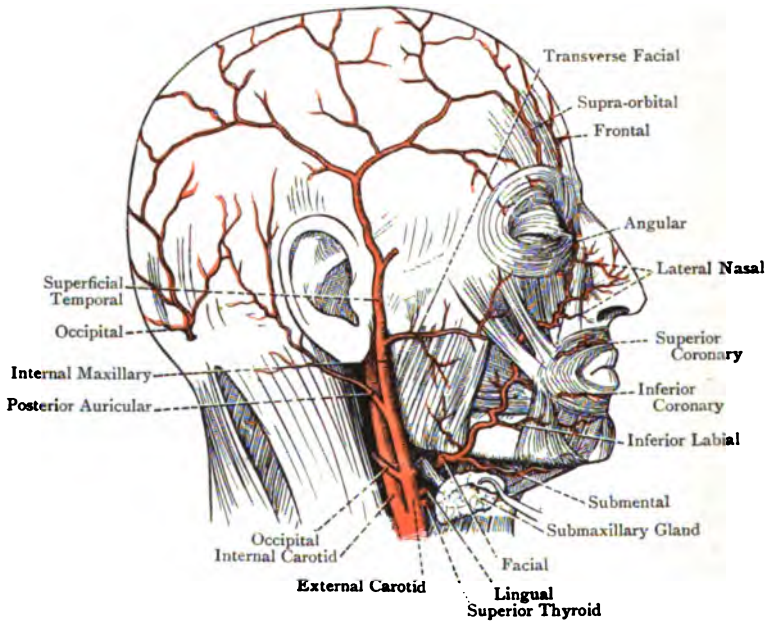

FIG. 463.—THE ARTERIES OF THE RIGHT SIDE OF THE HEAD (AFTER L. TESTUT'S 'ANATOMIE HUMAINE').

the nose; (4) a few inferior palpebral veins, which are in communication with the infra-orbital vein; (5) the superior labial vein, which issues from a plexus in the upper lip (the blood from the similar plexus in the lower lip being chiefly conveyed by a few vessels to the roof of the digastric triangle of the neck, where they take part in the formation of the anterior jugular vein); (6) the deep facial vein, of large size, which, emerging from the pterygoid plexus, appears from behind the anterior border of the ramus of the inferior maxilla and of the masseter muscle, and passes forwards over the buccinator; and (7) parotid, masseteric, and buccal branches.

Transverse Facial Artery.—This vessel arises from the superficial

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temporal in the parotid gland, and passes horizontally forwards. After emerging from beneath the anterior border of the gland it crosses the masseter, having the zygoma above it and Stensen's duct below it, the infra-orbital branches of the facial nerve being, in turn, below Stensen's duct. The order of structures from above downwards is, accordingly, artery, duct, and nerves. The artery is distributed to the parotid gland, the masseter muscle, and the structures on the side of the face, and it anastomoses with the infra-orbital, malar, facial, and buccal arteries.

The **transverse facial vein** opens into the superficial temporal vein.

The **nasal artery** is one of the terminal branches of the ophthalmic, and emerges from the orbit at the inner canthus above the internal tarsal ligament. It is distributed to the lachrymal sac and the side of the root of the nose, and anastomoses with the angular and lateral nasal arteries. It gives off a transverse nasal branch, which crosses the root of the nose and anastomoses with its fellow of the opposite side.

The **transverse nasal vein** connects the two angular veins over the root of the nose, and the other veins corresponding to the nasal artery open into the angular and superior ophthalmic veins.

The **supra-orbital** and **frontal arteries** have been already described (see pp. 992 and 993).

The **internal palpebral arteries,** *superior* and *inferior*, arise from the ophthalmic, and emerge from the orbit at the inner canthus, one passing above, and the other below, the internal tarsal ligament. Their course is outwards between the palpebral fibres of the orbicularis palpebrarum and the tarsal plates, and they anastomose, and form arches, with the palpebral branches of the lachrymal artery. They are distributed to the palpebral structures, the lachrymal sac, and the caruncula lacrimalis.

The **corresponding veins** from the upper eyelid open into the angular vein, and those from the lower eyelid into the facial vein.

The **terminal branch of the anterior ethmoidal artery** emerges, along with the terminal branch of the nasal nerve, between the lower border of the nasal bone and the upper lateral nasal cartilage. It is distributed to the skin of the tip, and the lower part of the side, of the nose.

The **external palpebral arteries,** *superior* and *inferior*, are branches of the lachrymal artery within the orbit. Their course is inwards between the palpebral fibres of the orbicularis palpebrarum and the tarsal plates, and they anastomose, and form arches, with the palpebral branches of the ophthalmic.

The **external palpebral veins** terminate in the orbital vein, which opens into the middle temporal vein, this in turn joining the superficial temporal vein.

The **temporal** and **malar arteries** are branches of the lachrymal, and they accompany the temporal and malar branches of the temporo-malar or orbital nerve.

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The **orbital** and **anterior temporal arteries** have been already described (see pp. 996 and 997).

The **infra-orbital artery** arises from the third part of the internal maxillary in the spheno-maxillary fossa. Having passed horizontally forwards, with the infra-orbital nerve, through the infra-orbital canal it emerges with that nerve through the infra-orbital foramen, lying under cover of the levator labii superioris muscle. It then gives branches upwards to the lower eyelid, inwards to the side of the nose, and downwards towards the upper lip. It anastomoses with the inferior palpebral, facial, transverse facial, and buccal arteries.

The **infra-orbital vein,** having traversed the infra-orbital canal, opens into the pterygoid plexus.

The **buccal artery** is a branch of the second part of the internal maxillary. It accompanies the long buccal nerve to the superficial surface of the buccinator muscle, and is distributed to that muscle and to the mucous membrane of the cheek. It anastomoses with branches of the facial artery.

The **mental artery** is one of the terminal branches of the inferior dental from the first part of the internal maxillary, and it emerges from the dental canal of the inferior maxilla, along with the mental nerve, through the mental foramen, lying under cover of the depressor anguli oris muscle. It supplies the structures in this vicinity, and anastomoses with the inferior coronary, inferior labial, and submental arteries.

The **mental vein** joins the inferior dental vein, which opens into the pterygoid plexus.

Lymphatics.—The lymphatics of the face are arranged in two sets, superficial and deep. The *superficial lymphatics* for the most part take a course similar to that of the facial vein, and terminate in the submaxillary lymphatic glands. They receive the lymphatics of (1) the inner portion of the frontal region at the inner canthus; (2) the inner portions of the eyelids; (3) the side of the nose; (4) the portion of the face between the lower eyelid and upper lip; and (5) the upper and lower lips. The lymphatics from the temporal and outer part of the frontal regions, from the front of the auricle, from the outer portions of the eyelids, and from the outer part of the cheek terminate in the parotid lymphatic glands. The *deep lymphatics*, including those of the orbit, anterior part of the nasal cavity, roof of the mouth, and temporal and zygomatic fossæ, terminate in the internal maxillary glands.

Parotid Lymphatic Glands.—These glands are situated partly superficial to the parotid gland, where they lie beneath the parotid fascia, and partly within the gland along the course of the external carotid artery. They receive their afferent vessels from the outer surface of the auricle, the external auditory meatus, the temporal and frontal regions, and the lateral parts of the face. Their efferent lymphatics pass to the upper superficial cervical, and upper group of the deep cervical, glands.

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Buccal Lymphatic Glands.—These glands are situated on the buccinator muscle. They receive their afferent lymphatics from the malar region and the lateral aspect of the face, and their efferent lymphatics pass to the parotid and submaxillary lymphatic glands.

Parotid Gland.—This salivary gland, which is of large size, is situated on the side of the face immediately in front of the auricle, and also below the auricle, where it occupies the space between the ramus of the lower jaw and the sterno-cleido-mastoid muscle. Its limits are as follows: *superiorly*, the zygoma; *inferiorly*, the stylo-maxillary ligament, in the direction of a line drawn from near the tip of the styloid process of the temporal bone to the angle of the inferior maxilla, this ligament separating it from the submaxillary gland; and *posteriorly*, the external auditory meatus, the mastoid process, and the anterior border of the sterno-cleido-mastoid muscle. The anterior border rests upon the posterior part of the masseter, and it is from this border, above its centre, that the parotid duct emerges. The duct is usually accompanied by a small portion of the gland, which lies above it, and may take the form of a distinct lobe. It is known as the *pars* or *glandula socia parotidis*. The superficial surface of the gland, which presents the usual lobulated appearance of compound racemose or acino-tubular glands, is covered by the parotid fascia, which is an upward extension of the deep cervical fascia. It is very dense, and consequently a parotid abscess is subjected to considerable tension. Lying beneath it, on the surface of the gland, there are the superficial set of parotid lymphatic glands. The deep connections of the gland are very intricate. It extends deeply between the mastoid process and sterno-cleido-mastoid behind, and the posterior border of the ramus and angle of the inferior maxilla in front. Superiorly, a deep extension of the gland, known as the *glenoid portion*, occupies the posterior part of the glenoid fossa, formed by the tympanic plate, and lying behind the fissure of Glaser. Lower down it extends both in front of, and behind, the styloid process and styloid muscles, and is here intimately related to the internal carotid artery, internal jugular vein, and glosso-pharyngeal, pneumogastric, spinal accessory, and hypoglossal nerves. The deep surface of the gland is invested by an upward extension of the deep cervical fascia, which, with the parotid fascia, forms a capsule for the gland. Anteriorly, the gland extends deeply behind the posterior border of the ramus of the lower jaw, as far at least as the posterior border of the internal pterygoid muscle, or it may be for a short distance between that muscle and the external pterygoid.

Several important structures traverse the gland. (1) The external carotid artery ascends deeply in it as high as the level of the neck of the inferior maxilla, where it divides into the superficial temporal and internal maxillary arteries, which are at first embedded in the gland. Whilst in the gland the superficial temporal artery gives off its transverse facial and auricular branches. (2) The super-

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ficial temporal and internal maxillary veins unite in the gland, at the level of the neck of the inferior maxilla, to form the temporo-maxillary vein, which descends from that level within the gland, lying superficial to the external carotid artery, and close to the lower border of the gland it breaks up into an anterior and a posterior division. (3) The external jugular vein is formed in the lower part of the gland by the union of the posterior auricular vein with the posterior division of the temporo-maxillary vein. (4) The facial nerve traverses the gland from behind forwards, and, in doing so, breaks up into its temporo-facial and cervico-facial divisions, the branches of which emerge from the gland anteriorly and superiorly. The nerve is superficial to the external carotid artery

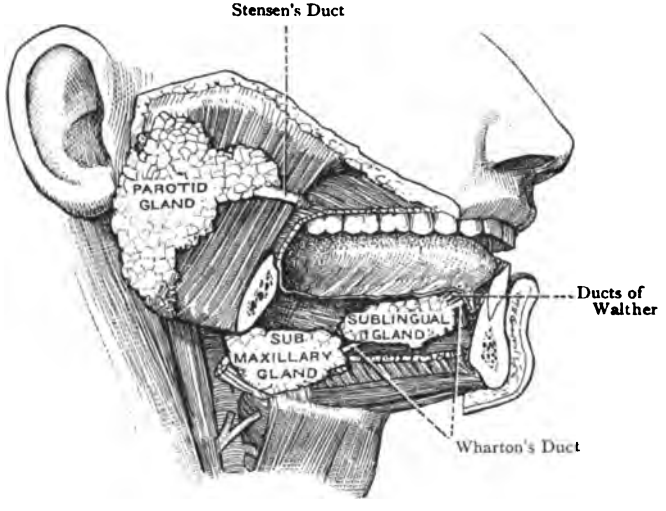

FIG. 464.—THE SALIVARY GLANDS OF THE RIGHT SIDE.

and temporo-maxillary vein. (5) Entering the lower part of the gland are branches of the great auricular nerve, which communicate within the gland with the facial nerve. (6) The auriculo-temporal nerve is related to the deep surface of the upper part of the gland, where it gives branches to it which communicate with the facial nerve.

Parotid Duct.—This excretory tube, which feels dense and tough, is usually called the duct of Stensen or Steno. It emerges from the anterior border of the gland, and passes forwards on the masseter muscle, lying fully ½ inch below the zygomatic arch. In this part of its course it is accompanied, for a short distance, by the pars or glandula socia parotidis, which, with the transverse facial artery, lies above it, whilst the infra-orbital branches of the facial nerve are placed below it. After leaving the surface of the masseter muscle the duct dips deeply through the fat covering the buccinator, and pierce-

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that muscle. Thereafter it passes forwards for a very short distance beneath the buccal mucous membrane, which it finally pierces to terminate in a minute opening on a small papilla situated opposite the crown of the *second* upper molar tooth. The duct is about the size of a crow-quill, its diameter being about $\frac{1}{8}$ inch, except at its buccal orifice, where it becomes narrow. It is about 2 inches in length, and its course may be indicated by a line drawn from the incisura intertragica, or from the junction of the lobule and cartilage of the auricle, to a point midway between the nostril and the red margin of the upper lip. About the middle third of this line corresponds to the duct.

Blood-supply.—The arteries are derived from (1) the extern l carotid, (2) the superficial temporal, (3) the transverse facial, and (4) the posterior auricular.

Lymphatics.—These pass to the superficial and deep cervical glands, having previously traversed the parotid lymphatic glands, and, in the case of some, the submaxillary lymphatic glands.

Nerve-supply.—(1) The auriculo-temporal nerve, which conveys to the gland secretory fibres of the glosso-pharyngeal nerve through its tympanic branch (Jacobson's nerve), the small superficial petrosal nerve, and the otic ganglion; (2) the great auricular nerve; (3) the sympathetic plexus on the external carotid artery; and (4) the facial nerve.

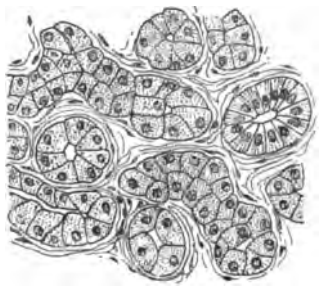

FIG. 465.—STRUCTURE OF THE PAROTID GLAND.

Structure.—The parotid gland is a compound racemose or acino-tubular gland, and is composed of large lobules, which are united by connective tissue. Each of these is made up of smaller lobules, likewise connected by connective tissue. Each small lobule is a gland on a minute scale, and is made up of a group of more or less saccu-lated tubules, called **alveoli** or **acini.** A duct passes from each small lobule, which unites with adjacent ducts, and these in turn unite, larger and still larger ducts being formed, the resultant being the principal duct, called Stensen's duct. Each alveolus is *serous* or *albuminous* as regards the nature of its secretion, and is composed of a basement membrane continuous with the wall of the duct, and surrounded by a plexus of capillaries. The alveolus is lined with polyhedral cells, which contain albuminous granules, and almost completely fill the tube, leaving only a small lumen. The first portion of the duct, called the *intercalary duct*, is lined with flattened epithelium. Beyond this the duct becomes constricted into a *neck*, which is lined with cubical cells, these being replaced in the intralobular duct by columnar cells. These cells are granular towards the lumen of the tube, but striated in the outer part. Each of the larger ducts is composed of a basement membrane. strengthened externally by a layer of connective tissue, superadded to which there is a stratum of plain muscular fibres.

Development.—The parotid gland appears in the early embryo as a small hypoblastic bud, situated in the angle between the maxillary and mandibular processes. This bud undergoes ramifications, which extend over the lower jaw, and so render the gland premandibular.

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Ocular Appendages.

The appendages of the eye consist of the eyelids and the lachrymal apparatus.

Eyelids.—The **eyelids,** or **palpebræ,** are two movable curtains, placed in front of the eyeball, to which they form an important protection. The inner surface of each is covered by mucous membrane, which constitutes the **conjunctiva.** The upper eyelid is larger than the lower, and, when closed, covers the transparent part of the eye or cornea. It is also more movable than the lower, being provided with a special elevator muscle, namely, the levator palpebræ superioris. The elliptical interval between the lids is called the **fissura palpebrarum,** and the lateral extremities of this fissure are called the outer canthus and inner canthus. The **outer canthus** is formed by the junction between the two lids. At the **inner canthus** the lids are separated by a recess, called the **lacus lacrimalis,** in which there is a small body, called the **caruncula lacrimalis.** In this region the eyelids are separated from the eyeball by a vertical, semilunar fold of the conjunctiva, called the **plica semilunaris.** The margin of each eyelid presents, at the commencement of the lacus lacrimalis, a slight conical elevation, called the **papilla lacrimalis,** the apex of which presents a small orifice, termed the **punctum lacrimale,** its direction being towards the eyeball. Each punctum is the entrance to a passage, called the **canaliculus lacrimalis,** by which the tears are conveyed from the surface of the eyeball into the lachrymal sac, and thence, through the nasal duct, into the inferior meatus of the nasal fossa.

The free margins of the eyelids, external to the puncta lacrimalia, are provided with hairs, called the **cilia** or **eyelashes.** They are short, stout, and curved, and are arranged in two rows. Those of the upper lid are more numerous and larger than those of the lower. The upper eyelashes are curved upwards, and the lower downwards, and in this manner intermingling is avoided. Within the lines of attachment of the eyelashes there is a row of modified sweat-glands, known as the **glands of Moll,** the openings of which are associated with the follicles of the eyelashes, and with the condition known as *stye.*

Structure of the Eyelids.—Each eyelid is composed of the following structures, in order from without inwards :

1. Skin.
2. Connective tissue.
3. Palpebral fibres of the orbicularis palpebrarum.
4. Tarsal plate.
5. Meibomian glands.
6. Conjunctiva.

In addition to the foregoing structures the upper eyelid contains the tendinous insertion of the levator palpebræ superioris muscle.

The **skin** is very thin, and at the ciliary margins of the eyelids it becomes continuous with the conjunctiva, which is a mucous membrane. The **subcutaneous connective tissue** is very loose, and

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devoid of fat. The **palpebral fibres of the orbicularis palpebrarum** form a very delicate, pale sheet. The **tarsal plate,** or **tarsus,** one for each eyelid, is a fibrous plate, and is composed of compact fibrous tissue. The **superior tarsal plate** is larger than the inferior, and is semilunar, its depth at the centre being about $\frac{1}{4}$ inch. Its upper and anterior part gives insertion to the levator palpebræ superioris. The **inferior tarsal plate** is narrow, and is almost of the same depth throughout. The *ciliary margins* of the tarsal plates are free, straight, and comparatively thick. The *orbital margins* are attached to the circumference of the orbit by membranous expansions, called the superior and inferior palpebral ligaments. The **superior palpebral ligament** is attached above to the upper part of the circumference of the orbit, where it blends with the periosteum, and below it blends with the tendon of insertion of the levator palpebræ superioris on the superior tarsal plate. The **inferior palpebral ligament** extends between the lower part of the circumference of the orbit and the lower margin of the inferior tarsal plate. The superior and inferior palpebral ligaments together constitute a partition, called the *septum orbitale,* which intervenes between the superficial and deep palpebral structures.

Externally and internally the tarsal plates have attachments by means of the tarsal ligaments, which are two in number, external and internal. The **external tarsal ligament** is formed by the junction of the superior and inferior palpebral ligaments, and is attached to the malar bone. The **internal tarsal ligament, tendo palpebrarum,** or **tendo oculi,** is independent of the palpebral ligaments. *Internally* it is attached to the external surface of the nasal process of the superior maxilla in front of the lachrymal groove. From this point it passes horizontally outwards for about $\frac{1}{8}$ inch, and then divides into two laminæ, which are attached to the superior and inferior tarsal plates. It passes in front of the lachrymal sac, and furnishes an offset, which passes behind the sac to be attached to the lachrymal crest of the lachrymal bone. The ligament gives origin to a few fibres of the orbicularis palpebrarum.

The **Meibomian glands** are situated on the internal surface of each tarsal plate, and lie between the plate and the conjunctiva at right angles to the ciliary margin. There are about thirty in the upper eyelid, and about twenty in the lower, and they are arranged in parallel rows, which occupy grooves on the ocular surface of each tarsal plate. Each gland opens by an independent orifice, and these orifices are arranged in a single row, lying a little behind the ciliary margin of the eyelid.

Structure.—The Meibomian glands are sebaceous glands, and their secretion lubricates the margins of the eyelids, and prevents them from adhering. Each consists of a tube, closed at one end, and having its sides beset with diverticula. The wall of the tube is composed of a basement membrane, which is lined with cubical epithelium throughout the greater part of the gland, but close to the orifice this is replaced by stratified epithelium.

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In the vicinity of the closed ends of the Meibomian glands there are some convoluted tubules, which are known as the **posterior tarsal,** or **accessory lachrymal, glands,** the orifices of which are placed close to the fornix conjunctivæ.

Conjunctiva.—This is the mucous membrane which covers the ocular surfaces of the eyelids and the front of the eyeball. It consists of two parts—palpebral and ocular.

The **palpebral conjunctiva** lines the ocular or inner surfaces of the eyelids, and, at their ciliary margins, it is continuous with the skin on their outer surfaces. It is also continuous, through the puncta lacrimalia, with the lining membrane of the lachrymal canals, lachrymal sac, nasal duct, and inferior meatus of the nose. In the region of the inner canthus it gives rise to the plica semilunaris, and at the outer part of the upper eyelid it is continuous with the lining membrane of the lachrymal ducts. The palpebral conjunctiva is fairly thick and highly vascular, and it presents numerous papillæ.

The **ocular conjunctiva** consists of two portions—sclerotic and corneal. It is continuous with the palpebral conjunctiva, and the line of reflection from the eyelids is known as the **fornix conjunctivæ, superior** and **inferior** respectively. In this vicinity the orifices of the posterior tarsal, or accessory lachrymal, glands are met with. The *sclerotic conjunctiva* covers the part of the sclerotic which is adjacent to the cornea. It is loosely connected to the sclerotic, is thin, non-papillary, and transparent, and contains only a few blood-vessels, the whiteness of the sclerotic being unaffected by it. The *corneal conjunctiva* is very thin, and consists only of the conjunctival epithelium.

The palpebral conjunctiva is covered by columnar epithelium, which, at the ciliary margin, passes into the stratified epithelium of the skin ; the sclerotic conjunctiva is also covered by columnar epithelium ; but the corneal conjunctiva is represented by the stratified epithelium of the cornea.

The conjunctiva is supplied with blood by offsets from the palpebral branches of the ophthalmic artery and its lachrymal branch. The vessels are disposed in a tortuous manner, and are movable upon the eyeball when the conjunctiva is pressed upon and displaced. The nerves are numerous, and form plexuses. The lymphatics commence close to the corneal margin in a network, from which vessels proceed to a network in each eyelid behind the tarsal plate. The efferent vessels ultimately reach the parotid and submaxillary lymphatic glands.

The **caruncula lacrimalis** occupies the lacus lacrimalis in the region of the inner canthus. It is a small, reddish, spongy body, consisting of a detached portion of skin, containing modified sweat and sebaceous glands. The latter open into the follicles of very delicate hairs with which the surface of the caruncle is provided, and they furnish the white secretion which may accumulate at the inner canthus.

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The **plica semilunaris** is a vertical, semilunar fold of the conjunctiva which is situated on the outer side of the caruncle, its concave margin being directed outwards. It corresponds to the *membrana nictitans*, or third eyelid, of some animals.

Development of the Eyelids.—The eyelids appear as two folds of the integument which unite along their margins about the third month of intra-uterine life. This union continues until shortly before birth, when they become separated.

Lachrymal Apparatus.—The constituent parts of the lachrymal apparatus are as follows :

1. The lachrymal gland.
2. The lachrymal canaliculi.
3. The lachrymal sac.
4. The nasal duct.

The **lachrymal gland** will be found described on p. 1071.

The **lachrymal canaliculi** are two in number, superior and inferior. They commence at the puncta lacrimalia on the summit of the

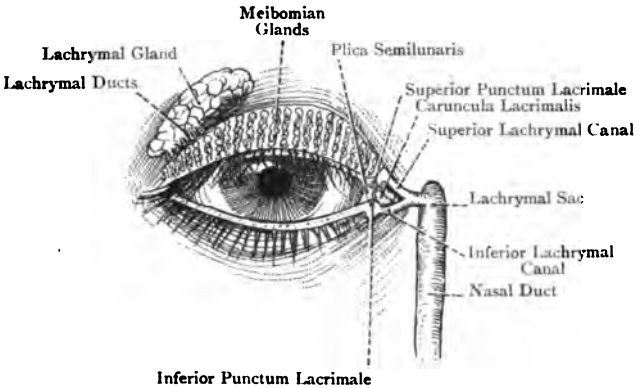

FIG. 466.—THE LACHRYMAL APPARATUS OF THE RIGHT EYE.

(The Meibomian Glands of the Upper Eyelid are also shown).

papillæ lacrimales, which latter are situated on the ciliary margins of the eyelids, close to the lacus lacrimalis. The **superior canaliculus** at first ascends vertically for about $\frac{1}{12}$ inch, after which it makes a sudden bend, and passes inwards and downwards to the lachrymal sac. The **inferior canaliculus** at first descends vertically for about $\frac{1}{12}$ inch, after which it makes a sudden bend and passes almost horizontally inwards to the lachrymal sac. The two canaliculi open into the lachrymal sac, either close together or by a common orifice, and their mucous membrane is lined with stratified squamous epithelium. The two slips of the tensor tarsi muscle are closely related to the horizontal portions of the canaliculi.

The **lachrymal sac** is the dilated upper part of the passage by which the tears are conveyed from the lachrymal canaliculi to the

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inferior meatus of the nose. It occupies the lachrymal groove of the lachrymal bone and nasal process of the superior maxilla. Superiorly it presents a round, closed extremity, and inferiorly it opens into the nasal duct. Externally it receives the lachrymal canaliculi, separately or conjointly, and anteriorly it is crossed by the tendo palpebrarum or internal tarsal ligament, which furnishes an offset round it. Posteriorly it is related to the tensor tarsi muscle.

The **nasal duct** extends from the lower end of the lachrymal sac to the anterior part of the inferior meatus of the nose, under cover of the front part of the inferior concha. Its length is about ¾ inch, and its diameter about ⅛ inch. It is directed downwards, outwards, and backwards, and its opening into the anterior part of the inferior meatus of the nose is usually guarded by an imperfect mucous fold, known as the **valve of Hasner.** The nasal orifice of the duct is about 1¼ inches from the anterior nasal aperture.

Structure of the Lachrymal Sac and Nasal Duct.—The wall is composed of fibro-elastic tissue, which adheres closely to the periosteum of the bones, and is covered by mucous membrane. The epithelial lining is of the columnar variety, and at intervals the cells are furnished with cilia. The mucous membrane is continuous superiorly with the conjunctiva through the lachrymal canaliculi and puncta, and inferiorly it is continuous with the nasal mucous membrane. In the nasal duct it may present one or two folds.

Development.—The lachrymal canaliculi, lachrymal sac, and nasal duct, are generally regarded as being developed from the cleft between the lateral nasal process and maxillary process, which extends from the inner canthus of the eye to the nasal cavity.

Auricle.

The auricle, or pinna, is that part of the external ear which projects from the side of the head. It is somewhat pyriform, with the broad end upwards, and it presents two surfaces, outer and inner.

The **outer surface** is irregularly concave, and presents certain elevations and depressions. About its centre there is a large deep fossa, called the **concha,** which leads to the meatus auditorius externus. Towards the upper and anterior part of the concha there is an elevation, called the **crus helicis,** which is directed upwards and forwards to the anterior border of the auricle. The concha is thus divided into two parts, upper and lower. In front of the concha there is a small, somewhat conical, prominence, called the **tragus,** which projects slightly backwards over the orifice of the meatus auditorius externus, and is provided with hairs on its inner aspect. A short distance behind the tragus, and on a lower level than it, there is another prominence, called the **antitragus,** which is separated from the tragus by a deep notch, called the **incisura intertragica.** The skin over the antitragus is also provided with hairs. Below the antitragus and incisura intertragica is the most dependent part of the auricle, called the **lobule,** which is comparatively soft in consistence. The prominent rim of the auricle is called the **helix.** It is incurved, and commences at the upper and anterior

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part of the concha in the crus helicis, already referred to. Thereafter it surrounds the upper part of the anterior margin, and the superior and posterior margins, of the auricle, and subsides below in the back part of the lobule. In some cases the helix presents a projection, called the **tubercle of Darwin,** which is situated on the incurved margin, slightly above the level where the antihelix, to be presently described, bifurcates into its crura. This projection is well developed in the ears of quadrupeds, and forms the *point* or *tip*. A short distance within the helix there is another curved elevation, called the **antihelix.** This commences inferiorly at the back part of the antitragus and ascends behind the concha, above

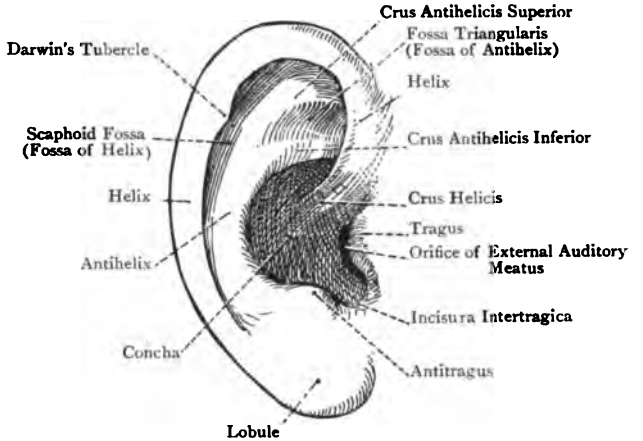

FIG. 467.—THE RIGHT AURICLE (EXTERNAL VIEW).

which it divides into two diverging crura, upper and lower. Between the helix and the antihelix is an elongated, narrow fossa, called the **fossa of the helix,** or the **scaphoid fossa,** and between the diverging crura of the antihelix there is a depression, called the **fossa of the antihelix** or the **triangular fossa.**

The **inner** or **cranial surface** of the auricle presents convexities corresponding to the fossæ on the outer surface, the convexity opposite the concha being especially prominent.

Structure of the Auricle.—The auricle, with the exception of the lobule, is composed of a plate of yellow elastic fibro-cartilage covered by skin. This plate imparts firmness and elasticity to it, and is provided with ligaments and intrinsic muscles. The skin is thin, and adheres closely to the fibro-cartilaginous plate. It is provided with hairs, which are most plentiful in the regions of the tragus and antitragus. The cartilage of the auricle is rolled upon itself so as to form the outer or cartilaginous part of the meatus auditorius externus. This portion of it is attached internally to the external auditory process of the temporal bone by fibrous tissue. The rolled or tubular portion presents a deficiency at the anterior and upper part, between the tragus and the commencement of the helix, which is occupied by a fibrous

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membrane. It also presents a variable number of transverse clefts, called the **fissures of Santorini,** which are filled with fibrous tissue. The lower extremity of the cartilage of the helix is separated from the cartilage of the antihelix by a deep cleft. The part of the cartilage of the helix behind this cleft is known as the **processus caudatus helicis.** At the upper and anterior part of the auricle, where the helix begins to curve backwards, the cartilage presents a small sharp projection, called the **spine of the helix.**

Ligaments of the Auricle.—These are two in number, anterior and posterior. The **anterior ligament** extends from the spine of the helix to the zygoma of the temporal bone close to its root.

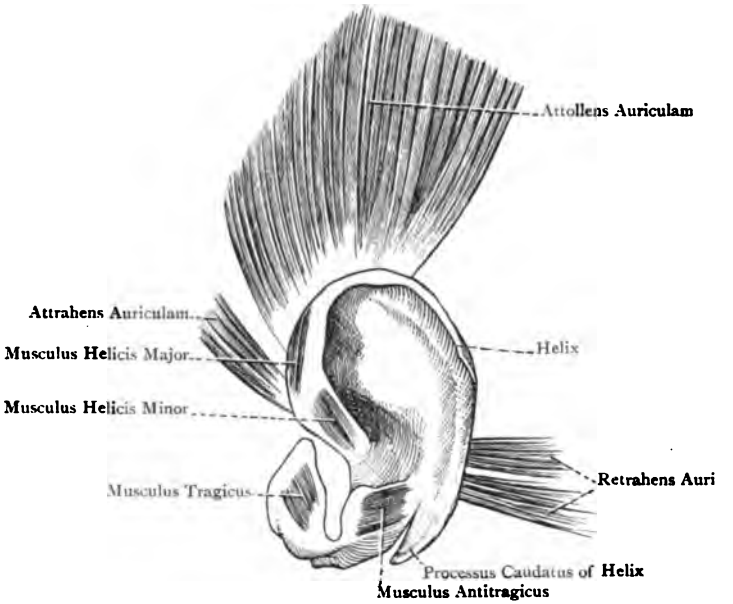

FIG. 468.—THE OUTER SURFACE OF THE LEFT AURICLE AND ITS MUSCLES (ARNOLD).

The **posterior ligament** extends from the cranial aspect of the concha, under cover of the retrahens auriculam muscle, to the mastoid process.

Intrinsic Muscles.—These muscles, which are very thin and pale, are confined to the auricle and are six in number, four being situated on the outer surface, and two on the inner surface.

Muscles on Outer Surface.—These are as follows : (1) the musculus helicis major ; (2) the musculus helicis minor ; (3) the musculus tragicus ; and (4) the musculus antitragicus.

The **musculus helicis major** extends from the spine of the helix along the anterior part of the helix as high as the level at which it curves backwards.

The **musculus helicis minor** lies upon the crus helicis.

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The **musculus tragicus** lies upon the outer surface of the tragus, its fibres being almost vertical.

The **musculus antitragicus** extends from the outer surface of the antitragus backwards and slightly upwards, to be attached to the processus caudatus of the helix.

Muscles on Inner Surface.—These are as follows : (1) the musculus transversus, and (2) the musculus obliquus.

The **musculus transversus** extends over the depression which corresponds to the antihelix on the outer surface, its attachments

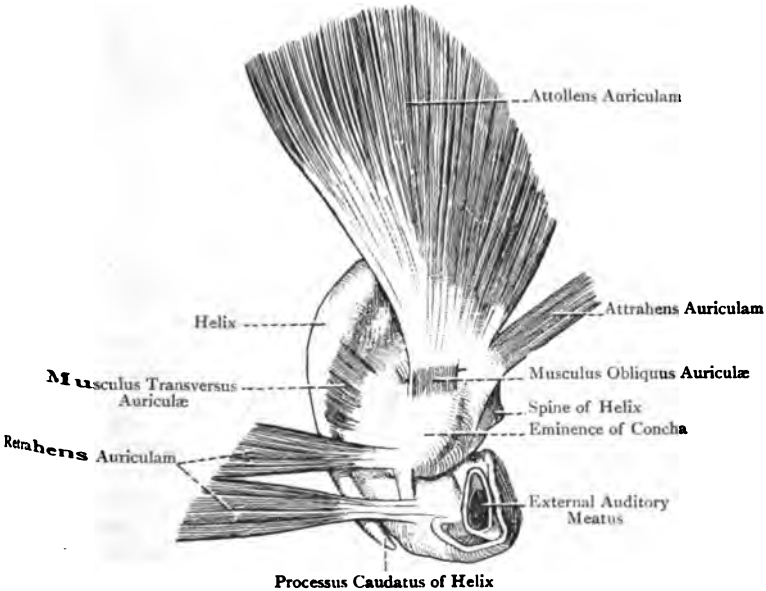

FIG. 469.—THE INNER SURFACE OF THE LEFT AURICLE AND ITS MUSCLES (ARNOLD).

being to the convexity of the concha on the one hand, and the convexity of the fossa of the helix on the other.

The **musculus obliquus** extends over the depression corresponding to the lower crus of the antihelix on the outer surface.

Action of the Intrinsic Muscles.—The musculus tragicus and musculus antitragicus diminish the orifice of the meatus auditorius externus, and the muscles of the helix, major and minor, have an opposite effect.

Nerve-supply.—The facial nerve.

Blood-supply of the Auricle.—The arteries are derived from (1) the posterior auricular branch of the external carotid, (2) the anterior auricular branches of the superficial temporal, and (3) the deep auricular branch of the first part of the internal maxillary,

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the last named giving offsets to the cartilaginous part of the meatus auditorius externus.

The **veins** terminate in the posterior auricular, superficial temporal, and internal maxillary veins, and one or two of them may open into the mastoid emissary vein.

The **lymphatics** pass to the mastoid glands and to the parotid lymphatic glands.

Nerve-supply.—The **inner surface** receives three cutaneous nerves, as follows: the great auricular supplies about the lower three-fourths, the small occipital about the upper fourth, and the auricular branch (Arnold's nerve) of the pneumogastric supplies the integument over the convexity of the concha. The **outer surface** is supplied by two cutaneous nerves, as follows: the auriculo-temporal nerve supplies the upper two-thirds, and the great auricular supplies the lower third. The motor nerve of the intrinsic muscles is, as stated, the facial nerve.

The Nose.

The nose, as it appears upon the face, presents a **root,** situated below the glabella of the frontal bone; a **tip,** or **point,** situated inferiorly; and a **dorsum,** which occupies an intermediate position. The upper part of the dorsum is known as the **bridge of the nose.** At the lower part of the nose there are the openings of the **nostrils,** or **anterior nares.** The outer margin of each nostril is slightly prominent and curved, and is called the **ala.** The nostrils are separated from each other by a septum, called the **columella nasi,** which, as well as the ala, is composed of fibrous tissue and skin. Within the circumference of each nostril there are several stout hairs or *vibrissæ.*

FIG. 470.—THE CARTILAGES OF THE NOSE (ANTERIOR VIEW) (ARNOLD).

The superficial or facial aspect of the nose derives its **arteries** from (1) the lateral nasal and angular branches of the facial, and (2) the nasal branch of the ophthalmic.

The **nerves** are derived from the nasal and infra-orbital nerves, the branches from the nasal being the infratrochlear and the terminal cutaneous offsets.

The lymphatics pass to the submaxillary lymphatic glands.

The framework of the nose is both osseous and cartilaginous.

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Cartilages of the Nose.—The nasal cartilages are five in number, as follows :

Upper lateral, right and left.
Lower lateral, right and left.
Septal.

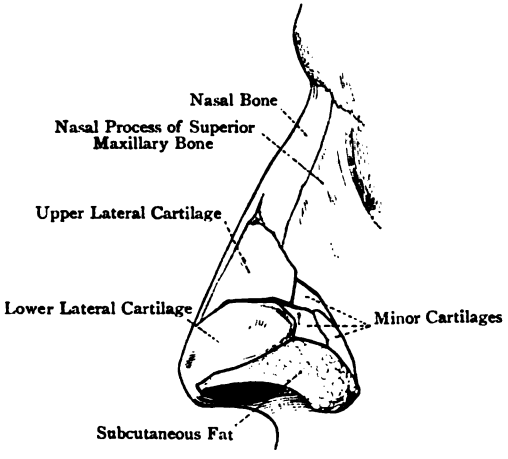

FIG. 471.—THE CARTILAGES OF THE NOSE (LATERAL VIEW) (ARNOLD).

The **upper lateral cartilages** are situated immediately below the nasal bones. They are triangular, and their *anterior borders* are continuous with each other, and with the anterior margin of the

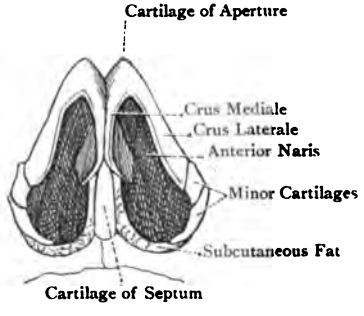

FIG. 472.—THE CARTILAGES OF THE NOSE (INFERIOR VIEW) (ARNOLD).

septal cartilage, in each case superiorly. Inferiorly, the anterior borders are separated by a slight interval, in which the anterior margin of the septal cartilage is visible. The *posterior border* of each cartilage is attached to the lower sloping border of the nasal bone, and also to the upper part of the nasal notch on the mesial

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border of the superior maxilla. The *lower border* is connected by fibrous tissue to the upper margin of the lower lateral cartilage.

The **lower lateral cartilages** are also known as the **cartilages of the apertures.** They are situated below the upper pair, and each is bent so as to lie in front, and on each side, of the nostril, which it keeps open. Its outer portion is called the crus laterale, and its inner portion the crus mediale.

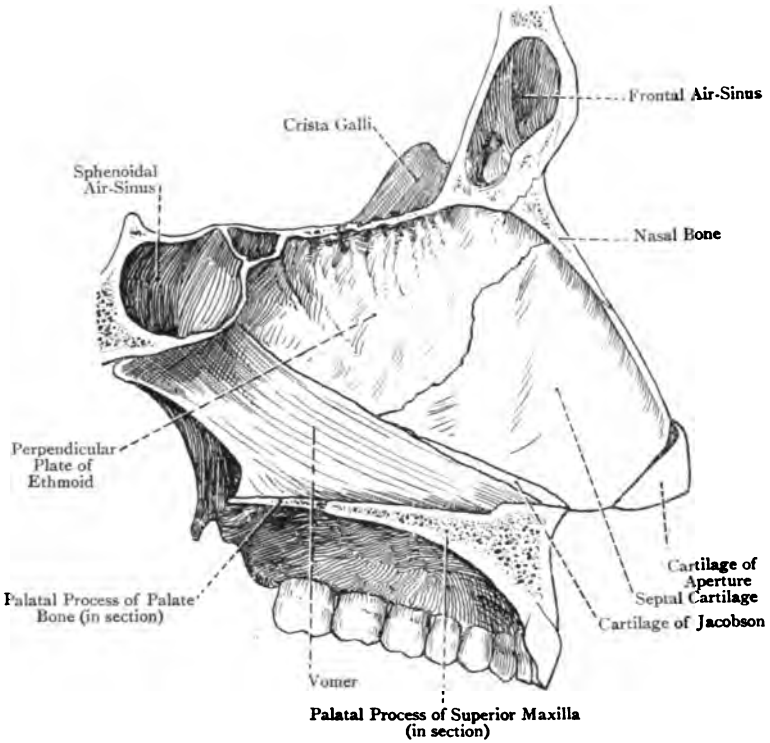

FIG. 473.—THE OSSEOUS AND CARTILAGINOUS NASAL SEPTUM (RIGHT LATERAL VIEW).

The *crus laterale* is attached by fibrous tissue to the upper lateral cartilage, and to the lower part of the nasal notch on the mesial border of the superior maxilla. The *crus mediale* is folded backwards, and is contiguous to its fellow of the opposite side. It lies along the upper part of the columella nasi, and along the antero-inferior border of the cartilage of the septum. Anteriorly it is separated from its fellow by a notch.

In the fibrous tissue which connects the crus laterale to the superior maxilla two or more isolated portions of cartilage are met with, called the **sesamoid** or **minor cartilages.**

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The lateral nasal cartilages are the remains of the fronto-nasal plate of the primitive cartilaginous skull.

The **cartilage of the septum** is mesially placed, and is usually inclined slightly to one side, most frequently the left. It forms a large part of the nasal septum anteriorly, and has the form of an irregularly four-sided, laterally-compressed plate. Its *anterior border* is attached to the back of the nasal bones, along the course of the internasal suture; below this it is connected to the anterior borders of the lateral nasal cartilages; and below these it lies between the crura medialia of the lower nasal cartilages. Its *posterior border* is accurately applied to the irregular anterior margin of the perpendicular plate of the ethmoid bone. Its *inferior border* is received into the front part of the groove on the anterior border of the vomer. The *antero-inferior border* passes upwards and forwards from the front part of the inferior border to the anterior border. In early life the septal cartilage is prolonged backwards to the body of the sphenoid bone in the form of a narrow strip, which intervenes between the lower border of the perpendicular plate of the ethmoid and the vomerine groove. This portion is known as the *sphenoidal* or *posterior process*. Along the inferior border of the septal cartilage, between it and the anterior border of the vomer, there are two narrow, elongated strips of cartilage, right and left, which are called the **cartilages of Jacobson,** or the **vomerine cartilages of Huschke.**

The septal cartilage is the persistent remains of the anterior extremity of the ethmo-vomerine plate of the primitive cartilaginous skull.

The Temporal and Ptergyo-maxillary Regions.

Muscles of Mastication.—These are four in number, namely, the masseter, temporal, external pterygoid, and internal pterygoid.

Masseter—*Origin*—(1) **Superficial Portion.**—The anterior two-thirds of the lower border of the zygomatic arch. (2) **Deep Portion.**—The posterior third of the lower border, and the whole of the deep or internal surface of the zygomatic arch.

Insertion.—The superficial portion is inserted into the lower half, and the deep portion into the upper half, of the outer surface of the ramus of the inferior maxilla. The superficial fibres extend as far as the angle, and the deep fibres encroach on the coronoid process.

Nerve-supply.—The masseteric branch of the anterior portion of the inferior maxillary division of the fifth cranial nerve. This branch emerges from the pterygoid region by passing over the sigmoid notch of the inferior maxilla, below the zygoma, and it therefore enters the muscle on its deep surface, accompanied by the masseteric artery.

The superficial portion of the muscle is directed downwards and slightly backwards, and the deep portion downwards and very slightly forwards.

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Action.—To elevate the inferior maxilla. The superficial portion also draws it slightly forwards.

Relations—*Superficial.*—The parotid gland and Stensen's duct, branches of the facial nerve, the transverse facial artery, the risorius, and the platysma myoides. *Deep.*—The ramus of the inferior maxilla, and the masseteric nerve and artery. The *anterior border* overlaps the buccinator, from which it is separated by the buccal pad of fat.

Temporal Muscle—*Origin.*—(1) The temporal fossa, extending as high as the inferior temporal ridge of the frontal and parietal bones, and as low as the infratemporal crest on the external surface of the great wing of the sphenoid, but excluding the portion of the fossa formed by the malar bone; and (2) the deep surface of the temporal fascia over its upper part.

Insertion.—(1) The internal surface, and superior and posterior borders, of the coronoid process of the inferior maxilla; and (2) the elongated triangular surface on the internal surface of the ramus of the inferior maxilla, close within the anterior border, and extending as low as a point on the inner side of the last molar alveolus.

Nerve-supply.—The deep temporal nerves, usually three in number, which are branches of the anterior portion of the inferior maxillary division of the fifth cranial nerve, and which enter the deep surface of the muscle.

The muscle is fan-shaped. The anterior fibres descend almost vertically; the middle fibres pass obliquely downwards and forwards; and the posterior fibres pass forwards almost horizontally.

Action.—To raise the inferior maxilla, that is, to draw it upwards into contact with the superior maxilla, as in closing the mouth. The posterior fibres also retract the inferior maxilla, and act in opposition to the external pterygoid, which protracts it.

Relations—*Superficial.*—The temporal fascia, supporting the attrahens and attollens auriculam muscles; the superficial temporal artery, auriculo-temporal nerve, and temporal branches of the facial nerve; the zygoma; and fat, which is continuous with the buccal pad. *Deep.*—The temporal fossa, the deep temporal arteries and nerves, and the external pterygoid muscle.

The long buccal nerve passes downwards and forwards under cover of the muscle close to the anterior border of the ramus of the inferior maxilla, and the masseteric nerve and artery pass forwards close to the posterior border in the region of the sigmoid notch of the inferior maxilla.

For the temporal fascia, see p. 999.

External Pterygoid—*Origin*—(1) **Upper Head.**—The zygomatic division of the outer surface of the great wing of the sphenoid, below the infratemporal crest. (2) **Lower Head.**—The outer surface of the external pterygoid plate of the sphenoid. The upper head is small, and the lower head is of large size.

Insertion.—(1) The depression on the front of the neck of the

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inferior maxilla ; and (2) the front of the interarticular fibro-cartilage of the temporo-mandibular joint.

Nerve-supply.—The external pterygoid nerve, which is a branch of the long buccal nerve, that, in turn, being a branch of the anterior portion of the inferior maxillary division of the fifth cranial nerve.

The direction of the muscle is backwards and slightly outwards.

Action.—(1) To draw forwards the neck and condyle of the inferior maxilla, and also the interarticular fibro-cartilage. When the muscles of opposite sides act in concert the inferior maxilla is protruded, and the lower incisor and canine teeth project beyond the level of those of the superior maxilla. The muscles of opposite sides, however, usually act in reciprocal succession, as in the

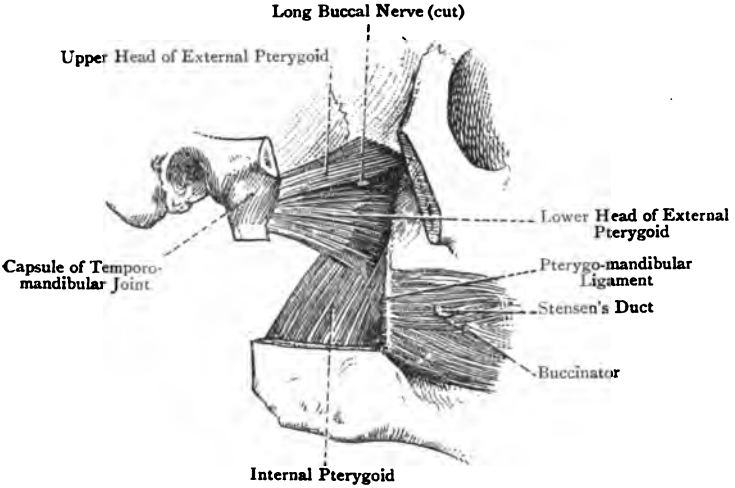

FIG. 474.—THE PTERYGOID AND BUCCINATOR MUSCLES.

oblique or grinding movement, the lower molars of one side being carried forwards and inwards upon the corresponding upper molars, and *vice versâ*. At the same time the elevators of the inferior maxilla are in action. (2) To take part in opening the mouth by drawing the condyle of the inferior maxilla and interarticular fibro-cartilage forwards on to the *eminentia articularis* of the temporal bone. The external pterygoid is antagonistic to the posterior portion of the temporal muscle.

Relations—*Superficial.*—Part of the ramus of the inferior maxilla, the lower part of the temporal muscle, part of the pterygoid plexus of veins, the long buccal nerve, and, it may be, the second part of the internal maxillary artery. *Deep.*—The upper portion of the internal pterygoid muscle, the spheno-mandibular ligament, in some cases the second part of the internal maxillary artery, the middle meningeal artery, a part of the pterygoid plexus of veins,

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the inferior maxillary nerve, the otic ganglion, and the chorda tympani nerve. *Superior.*—The masseteric and middle and posterior deep temporal nerves. *Inferior.*—The inferior dental and lingual nerves, and the spheno-mandibular ligament. The long buccal nerve, with the anterior deep temporal nerve, makes its appearance between the upper and lower heads, and the internal maxillary artery may sink between them.

Internal Pterygoid—*Origin.*—(1) The inner surface of the external pterygoid plate of the sphenoid, and the portion of the tuberosity of the palate bone which forms the lower part of the pterygoid fossa; and (2) the outer surface of the tuberosity of the palate bone, and the adjacent portion of the tuberosity of the superior maxilla.

Insertion.—(1) The inner aspect of the angle of the inferior maxilla; and (2) the back part of the inner surface of the ramus, between the angle and the dental foramen.

Nerve-supply.—The internal pterygoid branch of the anterior portion of the inferior maxillary division of the fifth cranial nerve.

The direction of the muscle is downwards, backwards, and outwards.

Action.—(1) To elevate the inferior maxilla; and (2) to draw it forwards.

Relations—*Superficial.*—The external pterygoid muscle to a slight extent superiorly, the spheno-mandibular ligament, the internal maxillary and inferior dental vessels, and the inferior dental and lingual nerves. *Deep.*—The tensor palati muscle, and the superior constrictor muscle of the pharynx.

For a description of the spheno-mandibular ligament, see p. 1136.

Internal Maxillary Artery.—This vessel is the larger of the two terminal branches of the external carotid. It arises from that artery opposite the neck of the inferior maxilla, and within the parotid gland. Its course is at first forwards and inwards behind the neck of the mandible, and superficial to the spheno-mandibular ligament. It then inclines upwards and forwards through the zygomatic fossa, usually passing superficial to the external pterygoid muscle, though in many cases it passes beneath it. Having reached the interval between the two heads of the external pterygoid, it sinks deeply between them, and, passing through the pterygo-maxillary fissure, it enters the spheno-maxillary fossa, where it gives off its terminal branches. In those cases where the artery passes beneath the external pterygoid muscle, it forms a projecting curve between the two heads of the muscle. The course of the vessel is very tortuous in adaptation to the mobility of the surrounding structures.

Owing to its complexity it is convenient to divide the artery into three parts, namely, first, second, and third. The **first, or mandibular, part** is situated between the neck of the inferior maxilla and the spheno-mandibular ligament, and its course is horizontally forwards and inwards. It is accompanied by the internal maxillary vein, and

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lies along the back part of the lower border of the external pterygoid muscle, crossing in front of the inferior dental nerve. The **second, or pterygoid, part** usually lies upon the lower head of the external pterygoid, and under cover of the insertion of the temporal muscle. Its course through the zygomatic fossa is upwards and forwards, and it sinks between the two heads of the external pterygoid on its way to the pterygo-maxillary fissure. In many cases, however, the second part of the vessel passes beneath the lower head of the external pterygoid, crossing in front of the internal pterygoid muscle and lingual nerve. Under these circumstances it forms a projecting curve between the two heads of the external pterygoid beneath the long buccal nerve. The **third, or spheno-maxillary, part** is situated in the spheno-maxillary fossa, which it enters by passing through the pterygo-maxillary fissure. In this fossa the vessel and its branches are intimately related to the superior maxillary nerve and Meckel's ganglion, with its branches.

Branches.—These are as follows :

First Part.	Second Part.	Third Part.
Deep auricular.	Masseteric.	Posterior dental.
Tympanic.	Internal pterygoid.	Infra-orbital.
Middle meningeal, giving off small meningeal.	External pterygoid.	Descending palatine.
	Posterior deep temporal.	Vidian.
	Anterior deep temporal.	Pterygo-palatine.
Inferior dental.	Buccal.	Spheno-palatine.

Branches of the First Part.—The **deep auricular artery,** of small size, ascends within the parotid gland, just behind the temporo-mandibular joint, and pierces the anterior cartilaginous wall of the meatus auditorius externus. It supplies the cutaneous lining of that passage, and the outer surface of the membrana tympani.

The **tympanic artery** may be associated with the preceding at its origin. It ascends beneath the external pterygoid, and enters the tympanic cavity by passing through the fissure of Glaser. It is distributed to the structures within the tympanum, and to the inner surface of the membrana tympani. Around the circumference of that membrane it forms an arterial ring with an offset of the stylo-mastoid artery, which is a branch of the posterior auricular.

The **middle meningeal artery,** of large size, ascends beneath the external pterygoid muscle, and, passing between the two roots of origin of the auriculo-temporal nerve, it enters the cranial cavity through the foramen spinosum in the sphenoid bone. It then passes upwards and forwards to the inner aspect of the antero-inferior angle of the parietal bone, where it divides into two branches, anterior and posterior, which ramify in the branching grooves on the inner surface of the parietal bone. The artery is accompanied by a plexus of sympathetic nerves, and by two veins. For the distribution of the vessel within the cranium, see p. 1356. Before disappearing through the foramen spinosum the middle meningeal

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artery usually gives off the *small meningeal artery*, which enters the cranial cavity through the foramen ovale (see p. 1356).

The **inferior dental artery** arises nearly opposite the middle meningeal artery, and descends upon the spheno-mandibular ligament in company with the inferior dental nerve, lying on its posterior and outer side. Having reached the inferior dental foramen, it gives off the small *mylo-hyoid artery*, and then it passes through the inferior dental foramen and enters the inferior dental canal which it traverses as far as the level of the mental foramen, where

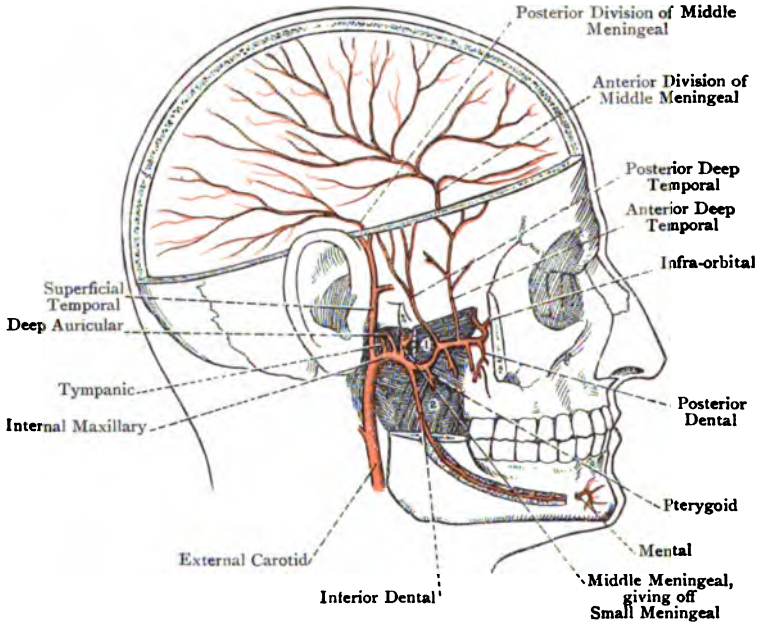

FIG. 475.—THE INTERNAL MAXILLARY ARTERY AND ITS BRANCHES.

(The Ramus of the Mandible and one half of the Calvaria have been removed).

it ends by dividing into its mental and incisor branches. Within the inferior dental canal the artery is accompanied by the inferior dental nerve and inferior dental vein.

Branches.—The *mylo-hyoid artery*, of small size, arises at the level of the inferior dental foramen. In company with the mylo-hyoid nerve it pierces the spheno-mandibular ligament, and descends in the mylo-hyoid groove to be distributed to the under surface of the mylo-hyoid muscle. The *molar*, *bicuspid*, and *canine branches* arise within the inferior dental canal, and supply the pulps of these teeth, which they reach by passing through the foramina on the extremities of their fangs. The *mental artery* emerges from the

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inferior dental canal through the mental foramen, and has been already described (p. 1106). The *incisor artery* supplies the pulps of the incisor teeth of one side.

Branches of the Second Part.—The branches of this part are muscular in their distribution. The **masseteric artery** passes outwards, with the corresponding nerve, over the sigmoid notch of the inferior maxilla, and enters the deep surface of the masseter. The **internal** and **external pterygoid branches** are distributed to the corresponding muscles. The **posterior** and **anterior deep temporal arteries** pass upwards to the posterior and anterior parts of the temporal fossa beneath the temporal muscle. They supply the muscle and the bones forming the fossa, and anastomose with the middle temporal artery, which is a branch of the superficial temporal. The anterior deep temporal artery also anastomoses with the lachrymal artery by twigs which pass through minute foramina in the outer wall of the orbit. The **buccal artery** passes downwards and forwards in company with the long buccal nerve, and is distributed to the buccinator muscle and the buccal mucous membrane which lines it internally.

Branches of the Third Part.—The **posterior dental artery** arises from the internal maxillary as it is about to pass through the pterygo-maxillary fissure into the spheno-maxillary fossa, and is sometimes associated with the infra-orbital artery at its origin. It descends upon the zygomatic surface of the superior maxilla, posterior to the malar process, and its principal branches traverse the posterior dental canals to supply the pulps of the upper molar teeth of one side. It also furnishes twigs to the mucous lining of the antrum of Highmore, and to the gum.

The **infra-orbital artery** arises in the spheno-maxillary fossa, sometimes in common with the posterior dental. It passes through the spheno-maxillary fissure in company with the superior maxillary nerve, and traverses the infra-orbital groove and canal on the floor of the orbit, the accompanying nerve being now called the infra-orbital nerve. From this canal it emerges through the infra-orbital foramen on to the face, where it has been already described (see p. 1106). The artery is accompanied by the infra-orbital vein. As the artery traverses the infra-orbital canal it furnishes (1) *orbital branches* to the structures on the floor of the orbit; and (2) the *middle* and *anterior dental arteries*, which descend in the middle and anterior dental canals in the superior maxilla, in company with the corresponding nerves, to supply the pulps of the upper bicuspid, incisor, and canine teeth of one side, and the mucous lining of the antrum of Highmore.

The **descending palatine artery** passes downwards in the posterior palatine canal, in company with the great or anterior descending palatine nerve, to the hard palate, where it passes forwards and inwards to the anterior palatine fossa. In this situation it furnishes a branch which ascends through the incisor canal, or canal of Stensen, to anastomose with the naso-palatine artery. As the artery

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traverses the posterior palatine canal it gives off a posterior and an external branch, which accompany corresponding nerves in the posterior and external accessory palatine canals, and supply the soft palate and tonsil.

The **Vidian artery** passes backwards through the Vidian canal in company with the Vidian nerve, and its branches are: (1) *pharyngeal*, to the upper part of the pharynx; (2) *Eustachian*, to the Eustachian tube; and (3) *tympanic*, to the tympanum.

The **pterygo-palatine artery,** of small size, passes backwards through the pterygo-palatine canal, in company with the pharyngeal nerve, and is distributed to the upper part of the pharynx, the Eustachian tube, and the mucous lining of the corresponding sphenoidal air-sinus.

The **spheno-palatine artery** enters the superior meatus of the nasal fossa through the spheno-palatine foramen. Its branches are distributed extensively on the outer wall of the nasal fossa, and supply the mucous membrane of the antrum, ethmoidal cells, and frontal air-sinus. One branch, called the *naso-palatine artery*, or *artery of the septum*, descends upon the septum to the incisor foramen, where it anastomoses with the ascending branch of the descending palatine artery.

Pterygoid Plexus of Veins.—This is a large plexus which surrounds the external pterygoid muscle. Its tributaries correspond, for the most part, to the branches of the internal maxillary artery, and are chiefly as follows: the deep auricular, tympanic, two middle meningeal, inferior dental, masseteric, pterygoid, deep temporal, buccal, superior dental, infra-orbital, palatine, and spheno-palatine. The blood is conveyed away from the plexus by two veins, namely, the internal maxillary and the deep facial.

The **internal maxillary vein** is a short vessel which issues from the posterior part of the plexus, and accompanies the first part of the internal maxillary artery. Opposite the neck of the inferior maxilla it joins the superficial temporal vein within the parotid gland to form the temporo-maxillary vein.

The **deep facial vein** issues from the anterior part of the pterygoid plexus, and, passing downwards and forwards, it emerges from behind the mandibular ramus and masseter muscle, and joins the facial vein on the buccinator muscle. The pterygoid plexus establishes the following important connections superiorly: it communicates with the intracranial cavernous sinus by means of emissary veins, which pass through the foramen ovale, foramen Vesalii, and foramen lacerum medium; and it communicates with the inferior ophthalmic vein at the spheno-maxillary fissure.

Internal Maxillary Lymphatic Glands.—These glands lie along the internal maxillary artery, upon the back part of the buccinator muscle, and upon the upper part of the lateral wall of the pharynx. They receive their afferent lymphatics from the following sources: the temporal and zygomatic regions, the orbit, the posterior two-thirds of the nasal fossa, the soft palate and roof of the mouth,

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the upper part of the pharynx, and the meninges of the brain. Their efferent vessels pass to the upper group of deep cervical glands.

Inferior Maxillary Nerve.—This is the **third division** of the fifth nerve. It is a mixed nerve, and consists of two roots—sensory and motor. The *sensory root*, which is of large size, arises from the Gasserian ganglion, and the *motor root* represents the entire motor root of the fifth nerve. Both roots leave the cranial cavity through the foramen ovale, and immediately after their exit they unite to form a mixed nerve, that is to say, a nerve composed of both sensory and motor fibres. This nerve is very short, and lies deeply in the zygomatic fossa, under cover of the external pterygoid muscle, where it gives off two branches, namely, a recurrent branch, and the internal pterygoid nerve. Thereafter it immediately breaks up into two parts, known as the anterior and posterior divisions. The *recurrent branch* enters the cranial cavity through the foramen spinosum, along with the middle meningeal artery, and divides into two branches—anterior and posterior. The anterior branch is distributed to the adjacent dura mater, and the posterior branch passes through the fissure between the petrous and squamous parts of the temporal bone, to be distributed to the mucous lining of the mastoid cells. The *internal pterygoid nerve* arises from the deep surface of the undivided inferior maxillary nerve, and passes downwards to enter the deep surface of the internal pterygoid muscle. Close to its origin it is intimately related to the otic ganglion.

Anterior Division of the Inferior Maxillary Nerve.—This division is smaller than the posterior, and is principally motor in function, the only sensory branch furnished by it being the long buccal nerve. Its branches are as follows: (1) masseteric, furnishing the posterior deep temporal; (2) middle deep temporal; and (3) long buccal, giving off the external pterygoid and anterior deep temporal, after which it is purely sensory.

The *masseteric nerve* passes upwards beneath the upper head of the external pterygoid muscle, where it furnishes the posterior deep temporal nerve. It then passes outwards over the upper border of the external pterygoid, and over the sigmoid notch of the lower jaw, behind the temporal muscle, to enter the upper part of the masseter on its deep surface.

The *deep temporal nerves* are three in number—anterior, middle, and posterior. The *anterior deep temporal nerve* usually arises from the long buccal after it has emerged between the two heads of the external pterygoid. It passes upwards, superficial to the upper head of that muscle, and enters the anterior part of the temporal muscle on its deep surface. The *middle deep temporal nerve* is a direct branch of the anterior division of the inferior maxillary, and it ascends beneath the external pterygoid to enter the middle part of the temporal muscle on its deep surface. The *posterior deep temporal nerve* springs from the masseteric nerve beneath the

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upper head of the external pterygoid, and, passing upwards, it enters the posterior part of the temporal muscle on its deep surface.

The *long buccal nerve* passes outwards between the two heads of the external pterygoid, and then downwards and forwards in contact with the inner surface of the temporal muscle at its insertion. Having emerged from underneath the mandibular ramus and anterior border of the masseter, it is received upon the outer surface

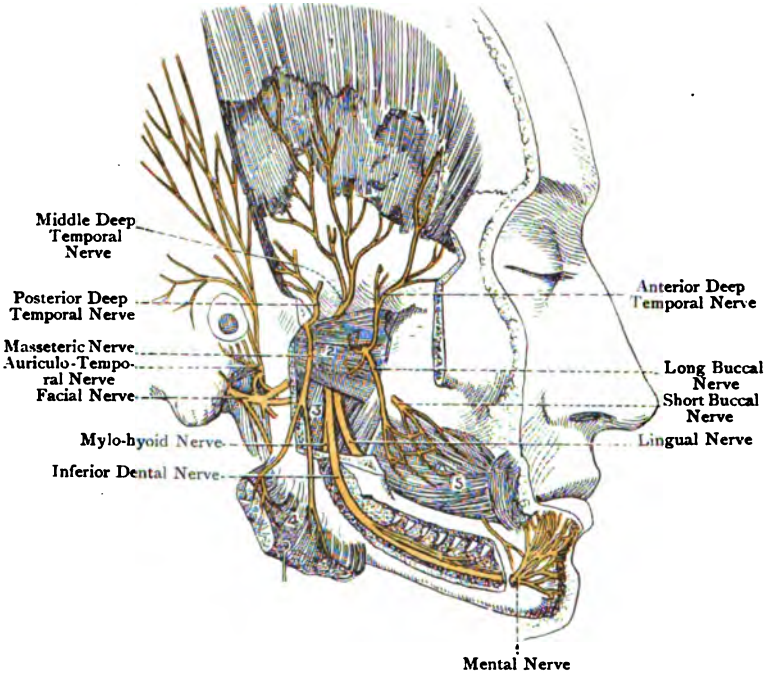

FIG. 476.—THE NERVES OF THE TEMPORAL AND PTERYGO-MAXILLARY REGIONS (HIRSCHFELD AND LEVEILLÉ).

1, Temporal Muscle; 2, External Pterygoid; 3, Internal Pterygoid; 4, Masseter; 5, Buccinator.

of the buccinator, where it communicates with the short buccal branches of the facial nerve to form the buccal plexus. Thereafter its terminal branches are distributed to the skin over the buccinator muscle and the mucous membrane which lines it. The long buccal nerve furnishes two branches, namely, the external pterygoid nerve and the anterior deep temporal nerve. The *external pterygoid nerve* is detached from it near its origin, and enters the external pterygoid muscle on its deep surface. The *anterior deep temporal nerve* arises from it after it has emerged between the two heads of the externa[l]

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pterygoid. These two branches conduct away all the motor fibres from the long buccal nerve, which thereafter is entirely sensory.

Posterior Division.—This division is larger than the anterior, and is almost entirely sensory, the only motor fibres which it contains being destined for the mylo-hyoid branch of the inferior dental nerve. Its branches are three in number, namely, (1) auriculo-temporal, (2) inferior dental, and (3) lingual (gustatory).

Auriculo-temporal Nerve.—This nerve, which is sensory, arises by two roots, between which the middle meningeal artery ascends to the foramen spinosum. Thereafter the two roots join, and the nerve is directed backwards under cover of the external pterygoid muscle. Having passed close behind the temporo-mandibular joint to the interval between that joint and the auricle, it enters the upper part of the parotid gland. It then changes its course, and passes upwards through the upper part of the gland, after emerging from which it crosses the zygoma and ascends close behind the superficial temporal artery to end in its terminal temporal branches.

Branches of Communication.—(1) Each root of the auriculo-temporal nerve receives a small branch from the otic ganglion. These branches contain fibres of the glosso-pharyngeal nerve, through means of (*a*) its tympanic branch (Jacobson's nerve), (*b*) the tympanic plexus, and (*c*) the small superficial petrosal nerve, which latter is reinforced by a branch from the geniculate ganglion of the facial nerve. These glosso-pharyngeal fibres are destined for the parotid gland. (2) Two communicating branches pass to the temporo-facial division of the facial nerve in the parotid gland.

Branches of Distribution.—(1) *Articular branches* enter the temporo-mandibular joint through the back part of the capsule. (2) *Glandular branches* are distributed to the parotid gland, to which they conduct fibres of the glosso-pharyngeal nerve. (3) *Meatal branches*, upper and lower, enter the meatus auditorius externus between its cartilaginous and osseous parts, and supply the skin which lines it, the upper branch also giving twigs to the outer layer of the membrana tympani. (4) *Anterior auricular branches* are distributed to the skin of the tragus and the upper part of the outer surface of the auricle. The distribution of the meatal and auricular branches explains why pain, due to affections of the lower teeth, may be referred to the ear canal and auricle. (5) The *temporal branches* are terminal. They accompany the branches of the superficial temporal artery, and supply the skin of the temporal region as high as the vertex of the skull. They communicate with the temporal branches of the facial, and the temporal branch of the temporo-malar from the superior maxillary nerve.

Inferior Dental Nerve.—This nerve, though chiefly sensory, contains motor fibres, which, however, leave it in its mylo-hyoid branch. It passes downwards, being at first under cover of the external pterygoid muscle. After escaping from beneath that muscle, it

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descends upon the spheno-mandibular ligament and internal pterygoid muscle to the inferior dental foramen, through which it passes into the inferior dental canal, after having parted with its mylo-hyoid branch. The lingual nerve is anterior and internal to it, and the inferior dental artery is posterior and external to it. Within the dental canal the nerve is accompanied by the inferior dental artery, and, having arrived at the level of the mental foramen, it terminates by dividing into two branches, mental and incisor.

Branches.—(1) The **mylo-hyoid nerve** is given off from the parent trunk just before it passes through the inferior dental foramen. It conducts away all the motor fibres from the parent trunk, and in company with the mylo-hyoid artery pierces the lower part of the spheno-mandibular ligament, and then passes downwards and forwards in the mylo-hyoid groove of the inferior maxilla. The nerve and artery are maintained in position within this groove by an expansion from the lower part of the spheno-mandibular ligament, which is attached to the lips of the groove. Thereafter the nerve passes forwards on the inferior surface of the mylo-hyoid muscle, under cover of the superficial part of the submaxillary gland. Having furnished twigs to the mylo-hyoid muscle, it terminates in the anterior belly of the digastric.

(2) The **dental branches** arise from the parent trunk, whilst it traverses the inferior dental canal. They communicate with each other to form a delicate plexus, from which branches are given off to the pulps of the lower molar and bicuspid teeth, as well as to the adjacent part of the gum. The pulp-branches correspond in number to the fangs of the teeth, and each enters through a minute opening on the extremity of the fang.

(3) The **mental nerve** is one of the two terminal branches. It emerges from the inferior dental canal through the mental foramen. For its distribution, see p. 1101.

(4) The **incisor nerve** represents the termination of the inferior dental. It commences at the level of the mental foramen, and passes almost as far as the middle line. Its dental branches communicate in a plexiform manner, and supply the pulps of the lower canine and incisor teeth, as well as the adjacent portion of the gum.

Lingual Nerve.—This nerve is sensory. It descends under cover of the external pterygoid muscle, lying anterior and internal to the inferior dental nerve. Whilst under cover of that muscle it receives near its origin the chorda tympani nerve, which joins it from behind at an acute angle, in a direction downwards and forwards, after emerging from the tympanum through the iter chordæ anterius, or canal of Huguier. After issuing from beneath the external pterygoid muscle the lingual nerve passes downwards and forwards between the internal pterygoid muscle and the mandibular ramus, and over the mandibular fibres of the superior constrictor muscle. Below the level of the third lower molar tooth it lies immediately beneath the mucous membrane of the mouth, and is

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here accessible for operative purposes. Thereafter it crosses the stylo-glossus, and passes forwards over the hyo-glossus close to the side of the tongue. Upon the latter muscle it describes a slight curve with the convexity downwards. It then passes beneath the mylo-hyoid muscle, where it lies above the deep part of the submaxillary gland and Wharton's duct, and has the submaxillary ganglion suspended from it. Finally, having crossed Wharton's duct from above downwards, it continues its course as far as the tip of the tongue. As it passes along the side of the tongue the nerve is immediately beneath the mucous membrane.

Branches of Communication.—(1) *Chorda tympani*, from the facial; (2) two branches to the submaxillary ganglion; and (3) one

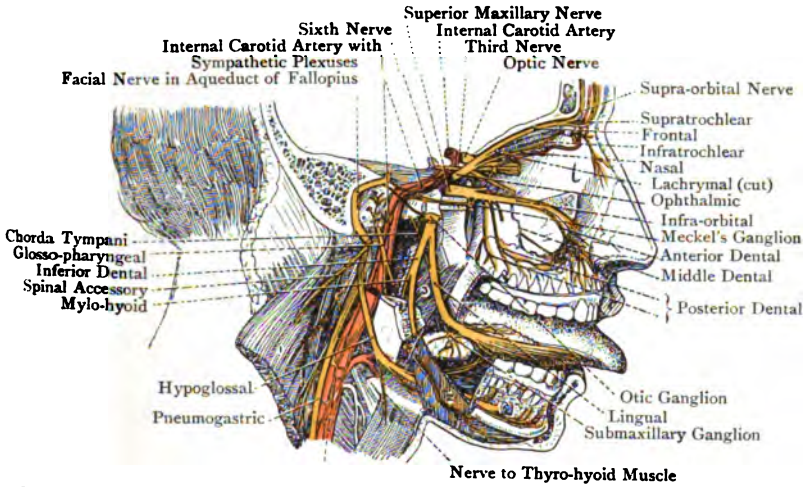

FIG. 477.—GENERAL VIEW OF THE FIFTH CRANIAL NERVE (HIRSCHFELD AND LEVEILLÉ).

1. Sterno-cleido-mastoid; 2, Mylo-hyoid; 3, Internal Pterygoid.

or two filaments to the hypoglossal nerve at the anterior border of the hyo-glossus muscle.

Branches of Distribution.—(1) *Buccal*, to the mucous membrane of the floor of the mouth and of the gums; (2) *glandular*, to the sublingual gland; and (3) *lingual*, to the mucous membrane of the sides and dorsum of the tongue over its *anterior two-thirds*. These lingual branches pierce the muscular tissue of the tongue, and are destined chiefly for the conical and fungiform papillæ.

Otic Ganglion.—The otic ganglion, or Arnold's ganglion, is a small oval body, of a pinkish colour, which is situated close to the foramen ovale, on the deep surface of the inferior maxillary nerve at the place of origin of the internal pterygoid nerve, with which it is closely connected. It has the middle meningeal artery

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behind it, and the cartilaginous part of the Eustachian tube on its inner side. The ganglion has three roots. One root (motor-sensory) is derived from the internal pterygoid nerve, and conveys to the ganglion motor fibres, and probably also sensory fibres. A second root (sensory-motor) is represented by the small superficial petrosal nerve, which joins the back part of the ganglion. This root also conveys to the ganglion sensory and motor fibres. The sensory fibres come from the glosso-pharyngeal, through means of (1) the tympanic nerve or nerve of Jacobson, (2) the tympanic plexus, and (3) the small superficial petrosal. The motor fibres conveyed by this root come from the geniculate ganglion of the facial nerve, through means of the branch which that ganglion gives

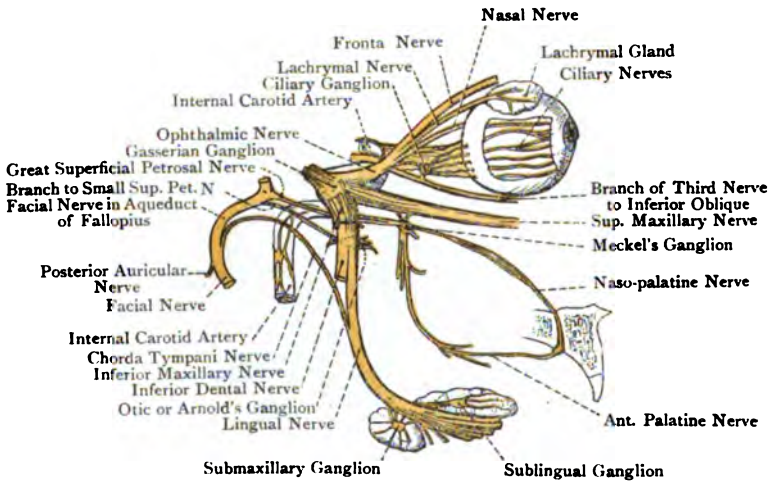

FIG. 478.—SCHEME OF THE FIFTH CRANIAL NERVE AND ITS GANGLIA (HIRSCHFELD AND LEVEILLÉ).

to join the small superficial petrosal nerve. The third root (sympathetic) comes from the sympathetic plexus around the middle meningeal artery.

Branches—(1) **Of Communication.**—(*a*) Two branches pass to the auriculo-temporal nerve, one to each root. These convey to that nerve glosso-pharyngeal fibres which are destined for the parotid gland. (*b*) A branch joins the chorda tympani. (*c*) A branch joins the Vidian nerve.

(2) **Of Distribution.**—Muscular branches are given to the tensor tympani and tensor palati.

Submaxillary Ganglion.—This ganglion is of small size, and is connected with the lingual nerve in the submaxillary region. It is situated upon the upper part of the hyo-glossus muscle, between the lingual nerve and the deep part of the submaxillary gland, and

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under cover of the posterior part of the mylo-hyoid muscle. It is suspended from the lingual nerve by two connecting branches, posterior and anterior, which stand apart from each other. The *posterior branch* consists of fibres which are derived from the chorda tympani of the facial, and from the lingual nerve. This posterior branch may exist as two twigs. The *anterior branch* may be regarded as an offset from the ganglion to join the lingual. The sympathetic root of the ganglion is derived from the plexus on the cervical portion of the facial artery.

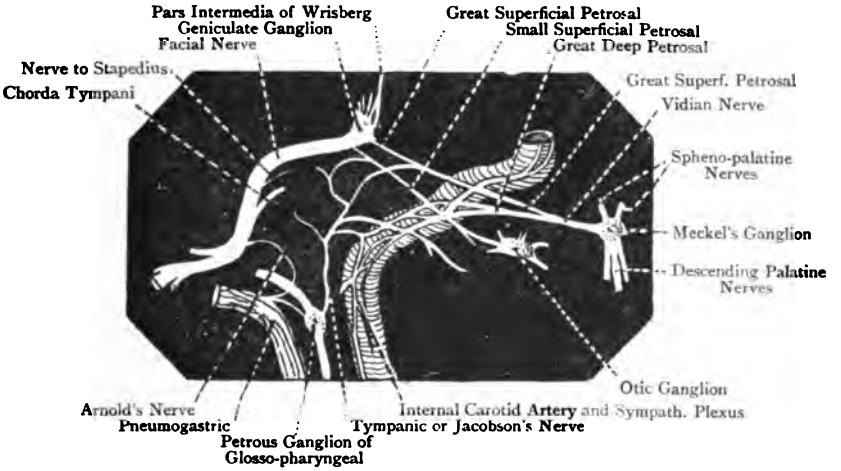

FIG. 479.—THE FACIAL NERVE IN THE AQUEDUCT OF FALLOPIUS, ETC. (HIRSCHFELD AND LEVEILLÉ).

Roots of the Submaxillary Ganglion.

Secretory.	Sensory.	Sympathetic.
From chorda tympani of facial.	From lingual.	From plexus on cervical portion of facial artery.

Branches.—These proceed from the lower and anterior parts of the ganglion, and are as follows : (1) glandular to the submaxillary gland ; (2) branches to Wharton's duct ; (3) buccal, to the mucous membrane of the floor of the mouth ; and (4) an anterior connecting branch, which passes to the lingual nerve. The anterior connecting branch probably consists of both chorda tympani and lingual fibres, and it accompanies the lingual nerve to the tongue. It furnishes twigs to the sublingual gland, and a small ganglion associated with these twigs has been described under the name of the sublingual ganglion.

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Summary of the Inferior Maxillary Nerve—1. **Cutaneous Distribution.**—It supplies (1) a portion of the dura mater, and the mucous membrane of the mastoid cells; (2) the skin over the greater part of the temporal region; (3) the skin of the external auditory meatus, and the outer surface of the membrana tympani; (4) the skin of the tragus, and of the upper part of the outer surface of the auricle; (5) the skin over the body of the inferior maxilla, including the skin of the chin and lower lip, as well as the mucous membrane of the lower lip; (6) the mucous membrane of the floor of the mouth, and the lower gum; and (7) the sides and dorsum of the tongue over its anterior two-thirds. 2. **Articular Distribution.**—It supplies the temporo-mandibular joint. 3. **Dental Distribution.**—It supplies the pulps of all the lower teeth of one side, and the mucous membrane of the outer surface of the lower gum of one side. 4. **Glandular Distribution.**—It gives branches to the parotid, submaxillary, and sublingual glands. 5. **Muscular Distribution.**—It supplies (1) the muscles of mastication, namely, the masseter, temporal, external pterygoid and internal pterygoid; (2) the mylo-hyoid and anterior belly of the digastric; and (3) the tensor palati and tensor tympani.

The Temporo-mandibular Joint.

The temporo-mandibular (temporo-maxillary) joint belongs to the class **diarthrosis,** and to the subdivision **condylarthrosis.** The articular surfaces are (1) the anterior part of the glenoid fossa, in front of the fissure of Glaser, and (2) the condyle of the mandible or inferior maxilla.

Ligaments.—These are as follows: the external lateral, capsular, internal lateral, stylo-mandibular, and interarticular fibro-cartilage.

The **external lateral ligament** is a short strong bundle of fibres, which is attached above to the tubercle and adjacent portions of the outer surface and lower border of the zygoma, and below to the condylar tubercle and the outer and back part of the neck of the mandible. Its fibres are directed obliquely downwards and backwards. This ligament forms the external portion of the capsular ligament.

The **capsular ligament** consists of scattered fibres which form a thin loose investment to the joint on its anterior, internal, and posterior aspects, being completed on the outer aspect by the external lateral ligament.

The **internal lateral,** or **spheno-mandibular, ligament** is a long flat band, which stands off from the joint, and therefore has no direct relation to it. It is somewhat triangular, being narrow above and broad below. Superiorly it is attached to the spinous process of the sphenoid bone, and inferiorly to the lingula and the inner margin of the inferior dental foramen of the mandible. Its fibres are directed downwards and slightly forwards. Superiorly it is covered by the external pterygoid muscle; subsequently the first part of the internal maxillary artery rests upon it, and separates it from the neck of the mandible; and inferiorly the inferior dental vessels and nerve and the auriculo-temporal nerve intervene between it and the ramus of the mandible. At its lower attachment it is spread over the upper end of the mylo-hyoid groove, and is here pierced by the mylo-hyoid nerve and artery. This ligament is

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sometimes spoken of as the *long internal lateral ligament*, in contradistinction to the internal portion of the capsule, which is regarded as the *short internal lateral ligament*.

The spheno-mandibular ligament represents a portion of the fibrous investment of Meckel's cartilage.

The **stylo-mandibular ligament** is a stout process of the deep cervical fascia, which extends from the styloid process of the temporal bone near its tip to the angle and adjacent portion of the posterior border of the ramus of the mandible. Superiorly it gives origin to a few fibres of the styloglossus, and inferiorly it is implanted between the masseter and internal pterygoid muscles. It separates the submaxillary gland from the lower portion of the parotid gland.

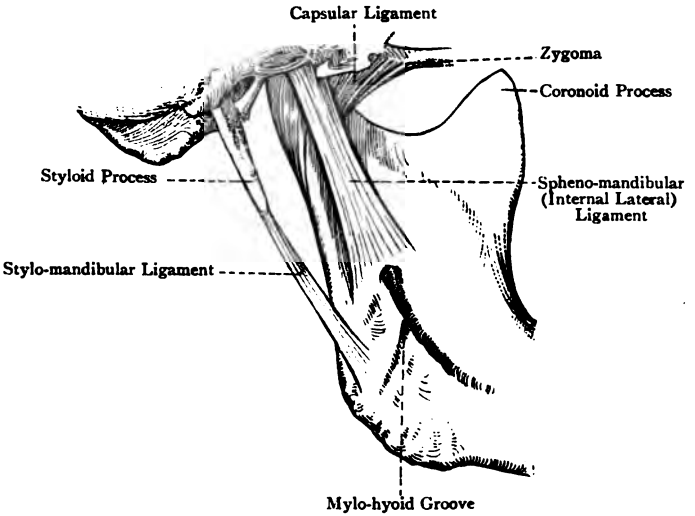

FIG. 480.—THE TEMPORO-MANDIBULAR JOINT (INTERNAL VIEW).

The **interarticular fibro-cartilage** is an oval plate which is interposed between the two articular surfaces. It is thinnest at the centre, where it is occasionally perforated, and thickest posteriorly. Its superior surface is concavo-convex from before backwards, in adaptation to the convexity of the eminentia articularis and the concavity of the glenoid fossa. Its inferior surface is concave, and fits upon the condyle of the mandible. Its circumference is connected with the capsular ligament, and anteriorly it gives partial insertion to the external pterygoid muscle. It divides the joint into two compartments, upper and lower, which are usually distinct.

The **synovial membranes** are two in number, upper and lower, one being above and the other below the plate of fibro-cartilage. The upper synovial membrane is larger and looser than the lower,

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and, when the plate of fibro-cartilage is perforated at the centre, the two synovial membranes are continuous through the perforation.

Arterial Supply.—The superficial temporal artery chiefly.

Nerve-supply.—The auriculo-temporal nerve and offsets from the masseteric nerve.

Movements.—These are as follows: (1) depression, (2) elevation, (3) protraction, (4) retraction, and (5) lateral movements. There being two divisions of the joint, upper and lower, different movements occur in each. The movement in the *upper compartment* is of a **gliding** character, whilst in the *lower compartment* it is of a **ginglymoid** or **hinge character**. When the mandible is depressed, as in opening the mouth, the condyle and the plate of fibro-cartilage move forwards on to the eminentia articularis. In cases of over-depression, as in violent yawning, or forcing too large a body into the mouth, the condyle is apt to slip over the eminentia articularis into the zygomatic fossa, and, when this takes place, dislocation of the mandible is the result.

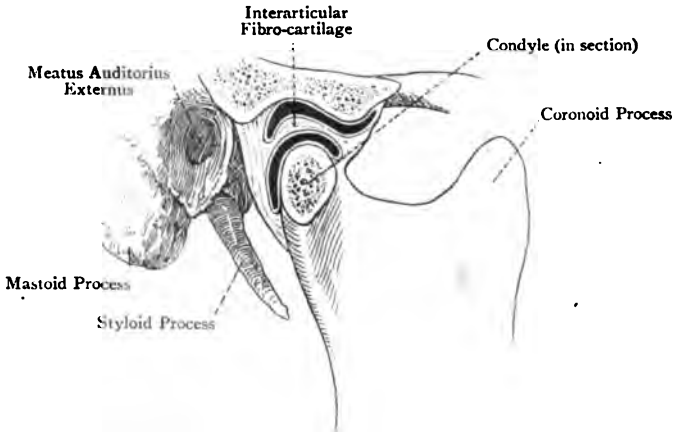

FIG. 481.—THE TEMPORO-MANDIBULAR JOINT OPENED (EXTERNAL VIEW).

The movement of forward gliding on the part of the condyle and plate of fibro-cartilage during depression takes place in the upper compartment of the joint. Another movement, however, of a ginglymoid or hinge character is taking place in the lower compartment of the joint, namely, between the condyle and the interarticular plate. This consists in the condyle rotating on the under surface of the plate round a transverse axis.

When the mandible is elevated, as in shutting the mouth, the changes which occur in both compartments of the joint are the reverse of those just described as taking place in depression. The condyle and fibro-cartilage glide backwards into the glenoid cavity, and at the same time the condyle rotates back to its previous position. In protraction, as when the lower incisors are protruded beyond the upper, and in retraction, the movement mainly takes place in the upper compartment of the joint, and consists in the condyle and plate of fibro-cartilage gliding forwards and backwards. When these movements are performed alternately on each side the lateral oblique movements, as in grinding or chewing, take place, and the condyle and fibro-cartilage of one side move forwards and backwards, whilst the other condyle and fibro-cartilage move in the opposite direction. During these movements **oblique rotation** is taking place in the lower compartment of the joint.

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Muscles Concerned in the Movements. — **Depression** is effected by the platysma myoides, mylo-hyoid, anterior belly of the digastric, and genio-hyoid muscles; and **elevation** by the anterior fibres of the temporal, masseter, and internal pterygoid muscles. **Protraction** is produced by the external pterygoid, the superficial fibres of the masseter, and slightly by the internal pterygoid; and **retraction** by the posterior fibres of the temporal, and the deep fibres of the masseter. The **grinding movement** is effected by the external pterygoid muscles acting alternately.

The Superior Maxillary Nerve.

The superior maxillary nerve is the second division of the fifth cranial nerve, and in size is intermediate between the inferior maxillary and the ophthalmic. It is entirely sensory, and arises from the Gasserian ganglion. Its course is forwards to the foramen rotundum, by which it leaves the cranial cavity. Thereafter it enters the posterior part of the spheno-maxillary fossa, and then crosses the upper part of that fossa to the spheno-maxillary fissure, through which it passes on to the floor of the orbit. It now takes on the name of the **infra-orbital nerve,** and traverses the infra-orbital groove, and then the infra-orbital canal, on the floor of the orbit. Finally, it emerges from this canal through the infra-orbital foramen, under cover of the levator labii superioris, and ends in its terminal branches. The course of the superior maxillary nerve (and its continuation under the name of the infra-orbital nerve) is almost directly forwards, there being a slight inclination outwards.

Branches.—These are as follows:

Intracranial.	**In Infra-orbital Canal.**
Recurrent meningeal.	Middle superior dental. Anterior superior dental.
In Spheno-maxillary Fossa.	**Facial.**
Orbital or temporo-malar.	Inferior palpebral.
Spheno-palatine.	Lateral nasal.
Posterior superior dental.	Superior labial.

The **recurrent meningeal branch** supplies the dura mater of the middle cranial fossa.

The **orbital** or **temporo-malar nerve** is the first branch of the superior maxillary in the spheno-maxillary fossa. It arises from its upper surface, and enters the orbit through the spheno-maxillary fissure. For its further course, see p. 1082.

The **spheno-palatine nerves** are two in number. They arise from the lower aspect of the parent trunk, and, after a very short descending course, they end for the most part in Meckel's ganglion, to which they convey sensory fibres, and of which they are the sensory roots. Many of their fibres, however, pass clear of the grey matter of the ganglion, and are prolonged into the nasal and descending palatine branches of the ganglion.

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The **posterior superior dental nerve** arises from the superior maxillary as it is about to pass through the spheno-maxillary fissure, and soon divides into two branches, which sometimes arise separately. They descend in grooves on the zygomatic surface of the superior maxilla, in company with branches of the posterior dental artery, and give off branches to the gum and contiguous part of the mucous membrane of the cheek. Thereafter they traverse the posterior dental canals, and within the substance of the bone they communicate with each other and with the middle superior dental nerve to form a delicate plexus, from which branches are given off to the pulps of the three upper molar teeth. Slender filaments are also furnished to the mucous membrane lining the antrum of Highmore.

The **middle superior dental nerve** arises from the main trunk as it lies in the infra-orbital groove near the spheno-maxillary fissure. It descends, in company with the middle dental artery, in the middle dental canal of the superior maxilla. Its branches communicate with each other, and with the posterior superior and anterior superior dental nerves within the substance of the bone, to form a delicate plexus, from which branches are given to the pulps of the upper two bicuspid teeth and to the gum. This nerve also furnishes delicate filaments to the mucous membrane lining the antrum of Highmore. Two enlargements are described in connection with the middle superior dental nerve. One is situated at its communication with the posterior superior dental nerve, and is known as the *ganglion of Valentin ;* and the other at its communication with the anterior superior dental, this one being known as the *ganglion of Bochdalek.*

The **anterior superior dental nerve** arises from the infra-orbital nerve near the front part of the infra-orbital canal, and descends, in company with the anterior dental artery, in the anterior dental canal. Its branches communicate with each other and with the middle superior dental nerve to form a delicate plexus, from which branches are given to the pulps of the upper canine and incisor teeth. This nerve also furnishes delicate filaments to the mucous membrane lining the antrum of Highmore, and a nasal branch, which enters the nasal fossa and supplies the mucous membrane of the anterior part of the inferior meatus and adjacent portion of the inferior concha.

The **facial branches** of the infra-orbital nerve, namely, inferior palpebral, lateral nasal, and superior labiae, have been already described, see p. 1101.

It is to be noted that there are three superior dental nerves, right and left, the *posterior* being a branch of the superior maxillary, and the *middle* and *anterior* being branches of the infra-orbital ; whilst there is only one inferior dental nerve, which is a branch of the inferior maxillary.

Spheno-palatine Ganglion.—This is also called **Meckel's ganglion.** It is a small triangular, somewhat reddish body, situated in the

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upper part of the spheno-maxillary fossa, close to the spheno-palatine foramen, which leads through the inner wall of the fossa to the superior meatus of the nasal fossa. It is suspended from the superior maxillary nerve by some of the fibres of the two spheno-palatine branches of that nerve, many fibres of these two branches, as stated, passing clear of the grey matter of the ganglion into its nasal and descending palatine branches. The fibres conveyed to the grey matter of the ganglion by the two spheno-palatine nerves represent its *sensory root* or *roots*. The *motor* and *sympathetic roots* are combined, and form the **Vidian nerve,** which joins the back part of the ganglion. The Vidian nerve

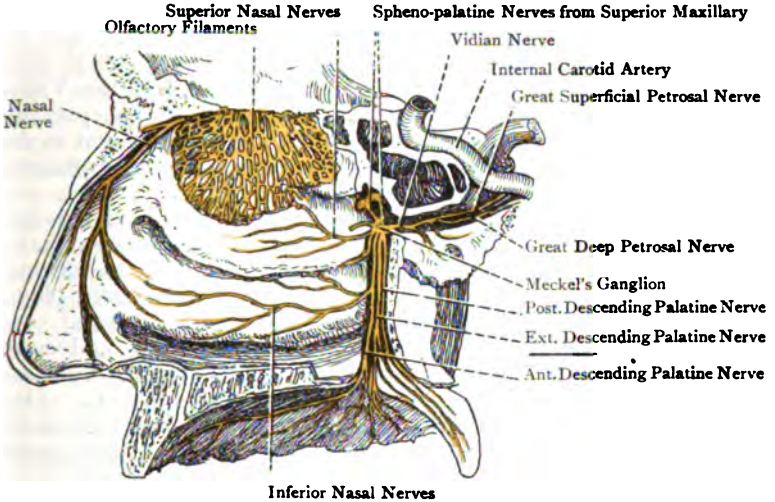

FIG. 482.—NERVES OF THE NASAL FOSSA, AND THE SPHENO-PALATINE OR MECKEL'S GANGLION, WITH ITS BRANCHES (INTERNAL VIEW) (HIRSCHFELD AND LEVEILLÉ).

is formed in the foramen lacerum medium by the junction of the great superficial petrosal nerve from the geniculate ganglion of the facial, and the great deep petrosal from the carotid plexus of the sympathetic. The great superficial petrosal nerve, though largely composed of sensory fibres, related to the pars intermedia of Wrisberg, also contains motor fibres, and so represents the motor root of Meckel's ganglion. The Vidian nerve traverses the Vidian canal from behind forwards, and thus enters the spheno-maxillary fossa, where it joins the back part of the ganglion. In the Vidian canal the Vidian nerve gives off one or two nasal branches, which pass through the floor of the canal, and are distributed to the mucous membrane of the posterior part of the roof of the nasal fossa and adjacent part of the septum.

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Branches of the Spheno-palatine Ganglion.—These are arranged in four sets, and are as follows :

Ascending.	Posterior.	Internal.	Descending.
Orbital.	Pharyngeal or pterygo-palatine.	Superior nasal.	Great or anterior palatine.
	Vidian.	Naso-palatine.	Small or posterior palatine.
			External palatine.

Ascending Branches. — These are called the **orbital branches.** They are two or three in number, and enter the orbit through the spheno-maxillary fissure, to be distributed to the periosteum. They have been described by Luschka as sending filaments through the inner wall of the orbit to supply the mucous membrane of the posterior ethmoidal cells and the sphenoidal air-sinus.

Posterior Branches.—These are the pharyngeal and the Vidian nerves. The **pharyngeal nerve** passes backwards in the pterygo-palatine canal, along with the pterygo-palatine artery, and is distributed to the mucous membrane of the upper part of the pharynx in the region of the Eustachian orifice.

The **Vidian nerve** (just described), if it is to be regarded as a posterior branch of the ganglion, establishes a communication between it and (1) the geniculate ganglion of the facial, through means of the great superficial petrosal, and (2) the carotid plexus of the sympathetic, through means of the great deep petrosal.

Internal Branches.—These are the superior nasal and naso-palatine nerves. The **superior nasal nerves** are of small size, and derive some of their fibres from the spheno-palatine nerves. They are about six in number, and, springing from the inner part of the ganglion, they enter the superior meatus of the nose through the spheno-palatine foramen. They supply the mucous membrane or the superior and middle conchæ, the superior meatus, the posterior ethmoidal cells, the middle meatus, and the upper and back part of the septum.

The **naso-palatine nerve** (*nerve of Cotunnius*) enters the nasal fossa along with the superior nasal nerves. It crosses the roof of the fossa, and then passes downwards and forwards upon the septum, lying in the groove on the lateral surface of the vomer. Having arrived at the region of the incisor crest, the **left** naso-palatine nerve descends through the *anterior* foramen or canal of Scarpa, and the right descends through the posterior. Having reached the anterior palatine fossa in this manner, the two nerves communicate in a plexiform manner, and delicate filaments are furnished to the mucous membrane of the hard palate behind the incisor teeth. In this situation communications are established with the great or anterior descending palatine nerve of each side. As the naso-palatine nerve traverses the groove on the lateral surface of the vomer, it furnishes twigs to the mucous membrane of the nasal septum, and in this part of its course it is accompanied by the naso-

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palatine artery (artery of the septum); but this artery does not accompany it through the foramen or canal of Scarpa.

Descending Branches.—These are the great or anterior, the small or posterior, and the external palatine nerves. They arise from the lower part of the ganglion, usually by a common trunk, and they derive some of their fibres from the spheno-palatine nerves.

The **great** or **anterior palatine nerve** descends in the posterior palatine canal, and escapes from it through the posterior palatine foramen. Thereafter it divides into branches which pass forwards and inwards, occupying grooves on the hard palate, to the mucous membrane and glands of which, as well as to the mucous membrane of the upper gum on its inner aspect, they are distributed. In the region of the anterior palatine fossa this nerve communicates with the naso-palatine nerve. As it descends in the posterior palatine canal, it furnishes **two inferior nasal nerves,** which enter the nasal fossa, and are distributed to the mucous membrane over the inferior concha, except anteriorly, and to that of the adjacent portion of the inferior meatus. The **small** or **posterior palatine nerve** descends in the posterior accessory palatine canal, after emerging from which it is distributed to the mucous membrane of the soft palate and tonsil. It may furnish branches to the levator palati and azygos uvulæ muscles, the fibres of these branches being derived from the geniculate ganglion of the facial through means of the great superficial petrosal, which contributes to the formation of the Vidian nerve, and conveys motor fibres to Meckel's ganglion. The two muscles in question, however, are most probably supplied by the bulbar part of the spinal accessory nerve through the pharyngeal plexus. The **external palatine nerve** descends through the external accessory palatine canal, after emerging from which it is distributed to the mucous membrane of the outer portion of the soft palate and tonsil.

Summary of the Superior Maxillary Nerve and Meckel's Ganglion—1. **Cutaneous Distribution.**—(1) The skin of the anterior part of the temporal region, and over the malar bone; (2) the skin from the lower eyelid down to the upper lip, including the skin of the side of the nose; (3) the mucous membrane of the naso-pharynx in the vicinity of the Eustachian orifice; (4) the mucous membrane of the nasal fossa; (5) the mucous membrane of the antrum of Highmore; (6) the mucous membrane of the soft palate and tonsil; and (7) the mucous membrane of the hard palate, with its glands, and that of the inner surface of the upper gum. 2. **Dental Distribution.**—The pulps of all the upper teeth of one side, as well as the mucous membrane of the outer surface of the upper gum.

In addition to the foregoing, the superior maxillary nerve supplies the periosteum of the orbit, and the dura mater of the middle cranial fossa.

Deep Dissection of the Neck.

Stylo-pharyngeus—*Origin.*—The base of the styloid process of the temporal bone on its inner aspect.

Insertion.—(1) The superior and posterior borders of the ala of the thyroid cartilage, and (2) the lateral wall of the pharynx, its

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fibres blending with those of the palato-pharyngeus and middle constrictor muscles.

Nerve-supply.—The glosso-pharyngeal nerve.

The muscle is directed downwards and inwards.

Action.—To elevate the pharynx and larynx.

The muscle passes between the superior and middle constrictor muscles. The glosso-pharyngeal nerve lies at first along its lower border, and then crosses over it on its way to the posterior part of the tongue.

Internal Carotid Artery.—The internal carotid artery is one of the terminal branches of the common carotid. It commences on a level with the upper border of the thyroid cartilage, and passes vertically upwards to the under surface of the petrous part of the temporal bone. Here it enters the carotid canal within the *pars petrosa*, and, after traversing this canal, it enters the cranial cavity. The vessel is divided into three parts—extracranial or cervical, petrous, and intracranial or cavernous.

Extracranial or Cervical Part.—This part of the vessel extends from the level of the upper border of the thyroid cartilage to the foramen caroticum on the inferior surface of the petrous part of the temporal bone. Its course is vertically upwards, and at first it lies in the carotid triangle, where it is placed external to, and behind, the external carotid artery.

Relations—*Anterior.*—This part of the vessel is comparatively superficial, being covered by the integument, platysma myoides, and sterno-cleido-mastoid, the latter overlapping it. After leaving the carotid triangle the artery becomes deeply placed, and passes beneath the posterior belly of the digastric and stylo-hyoid muscles, parotid gland, styloid process, and stylo-pharyngeus muscle. In this part of its course the vessel is crossed by the hypoglossal, glosso-pharyngeal, and pharyngeal branch of the pneumogastric, nerves, and by the occipital and posterior auricular arteries. The relation of the artery to the external carotid here undergoes a change. The level where the change takes place is as the internal carotid passes beneath the styloid process of the temporal bone, and the change consists in the external carotid taking up a position directly anterior to the internal carotid. The two arteries are, however, separated from each other by the following structures: (1) the styloid process; (2) the stylo-pharyngeus muscle; (3) the glosso-pharyngeal nerve; and (4) the pharyngeal branch of the pneumogastric nerve.

Posterior.—The rectus capitis anticus major, the superior cervical ganglion of the sympathetic, and the superior laryngeal branch of the pneumogastric nerve.

External.—The internal jugular vein and pneumogastric nerve, the nerve being on a plane posterior to both artery and vein. These three structures are still surrounded by a sheath which is an upward extension of the carotid sheath, previously described. Close to the base of the skull the glosso-pharyngeal, spinal accessory, and hypo-

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glossal nerves lie between the internal carotid artery and the internal jugular vein. The glosso-pharyngeal nerve soon passes forwards superficial to the artery, the spinal accessory nerve passes backwards superficial to the vein, and the hypoglossal nerve passes forwards superficial to the artery at the lower border of the posterior belly of the digastric muscle.

Internal.—The ascending pharyngeal artery, the lateral wall of the pharynx, the tonsil, and the superior laryngeal nerve.

Development.—The internal carotid artery is developed from the third arterial arch and the part of the dorsal aorta above it (see p. 940).

The Glosso-pharyngeal Nerve.

The glosso-pharyngeal or ninth cranial nerve is a mixed nerve, consisting of both afferent or sensory and efferent or motor fibres. It emerges from the cranial cavity through the middle compartment of the jugular foramen, along with the pneumogastric and spinal accessory nerves, but enclosed in a separate sheath of the dura mater, and lying on the outer side of, and anterior to, these two nerves. In passing through the jugular foramen, the nerve presents two ganglia, the upper one, which is small and situated in the upper part of the foramen, being called the jugular ganglion ; and the lower one, which is rather larger, being called the petrous ganglion. The latter is about $\frac{1}{4}$ inch in length, and lies in the lower part of the foramen, where it occupies a groove on the petrous portion of the temporal bone. After emerging from the jugular foramen, the nerve at first descends between the internal carotid artery and internal jugular vein, being external to the line of the pneumogastric nerve. It then passes downwards and forwards in front of the internal carotid artery, and under cover of the styloid process, stylo-pharyngeus muscle, and external carotid artery. It next curves round the lower border of the stylo-pharyngeus, and crosses its superficial surface in a forward direction. Finally, it passes beneath the hyo-glossus muscle, and so reaches the posterior third of the tongue, where it divides into its terminal branches.

The **jugular ganglion,** as stated, is very small, and involves only a few of the fibres of the nerve, the other fibres passing clear of, but close to, the ganglion, and being continued into the nerve beyond it. This ganglion neither gives nor receives any branches, and is sometimes absent.

The **petrous ganglion,** unlike the jugular, involves all the fibres of the nerve, and it furnishes connecting branches and the tympanic nerve.

Branches of the Glosso-pharyngeal Nerve—1. **From the Petrous Ganglion**—(*a*) *Branches of Communication.*—These are three in number, as follows : one to the superior cervical ganglion of the sympathetic ; one to the auricular branch of the ganglion of the root of the pneumogastric ; and one to the ganglion of the root of the pneumogastric.

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(*b*) *Branch of Distribution.*—This is called the *tympanic nerve*, or *nerve of Jacobson*. After leaving the petrous ganglion, it ascends, in company with the tympanic branch of the ascending pharyngeal artery, through the tympanic canaliculus. In this way it enters the tympanic cavity at the junction of the inner wall and floor, and ascends upon the inner wall. Being joined by the caroticotympanic branch of the carotid plexus of the sympathetic, it breaks up into branches which occupy grooves upon the promontory, and form the tympanic plexus. From this plexus the tympanic nerve emerges under the name of the small superficial petrosal nerve, which leaves the tympanic cavity and traverses a minute canal in the petrous bone, passing in its course beneath the upper portion of the canal which lodges the tensor tympani muscle. Whilst in this canal, it is joined by a communicating branch from the geniculate ganglion of the facial nerve. It emerges from the canal through the accessory hiatus on the superior surface of the petrous bone, which is external to the hiatus Fallopii, and then passes forwards and inwards beneath the dura mater. Thereafter it passes through the canaliculus innominatus, when present, or through the fissure between the *pars petrosa* and great wing of the sphenoid, or sometimes through the foramen ovale, into the zygomatic fossa, where it joins the otic ganglion, to which it conducts glosso-pharyngeal and facial fibres.

For a description of the tympanic plexus, see p. 1420.

2. **From the Trunk of the Nerve.**—(1) A *communicating branch* sometimes passes from the nerve a little below the petrous ganglion to join the digastric branch of the facial nerve. (2) A *carotid branch* passes to the sympathetic plexus on the internal carotid artery. (3) *Pharyngeal Branches.*—These are about four in number. Three of them unite, over the middle constrictor of the pharynx, with the subdivisions of the pharyngeal branch of the ganglion of the trunk of the pneumogastric, and with branches of the superior cervical ganglion of the sympathetic, to form the pharyngeal plexus. The other pharyngeal branch pierces the superior constrictor, and is distributed to the mucous membrane of the upper part of the pharynx. (4) A *muscular branch* to the stylo-pharyngeus muscle, some of the fibres of which pierce the muscle to supply the mucous membrane of the pharynx. (5) *Tonsillar branches* are given off near the tongue, which are distributed to the tonsil and the anterior and posterior pillars of the fauces. (6) *Lingual or Glossal Branches.*—Under cover of the hyo-glossus muscle, the terminal part of the nerve divides into two branches, dorsal and lateral. The *dorsal branch* passes to the dorsum of the tongue, and is distributed to the circumvallate papillæ and the mucous membrane over the posterior third, extending as far back as the front of the epiglottis. The *lateral branch* is distributed to the mucous membrane of the side of the tongue over about its posterior half.

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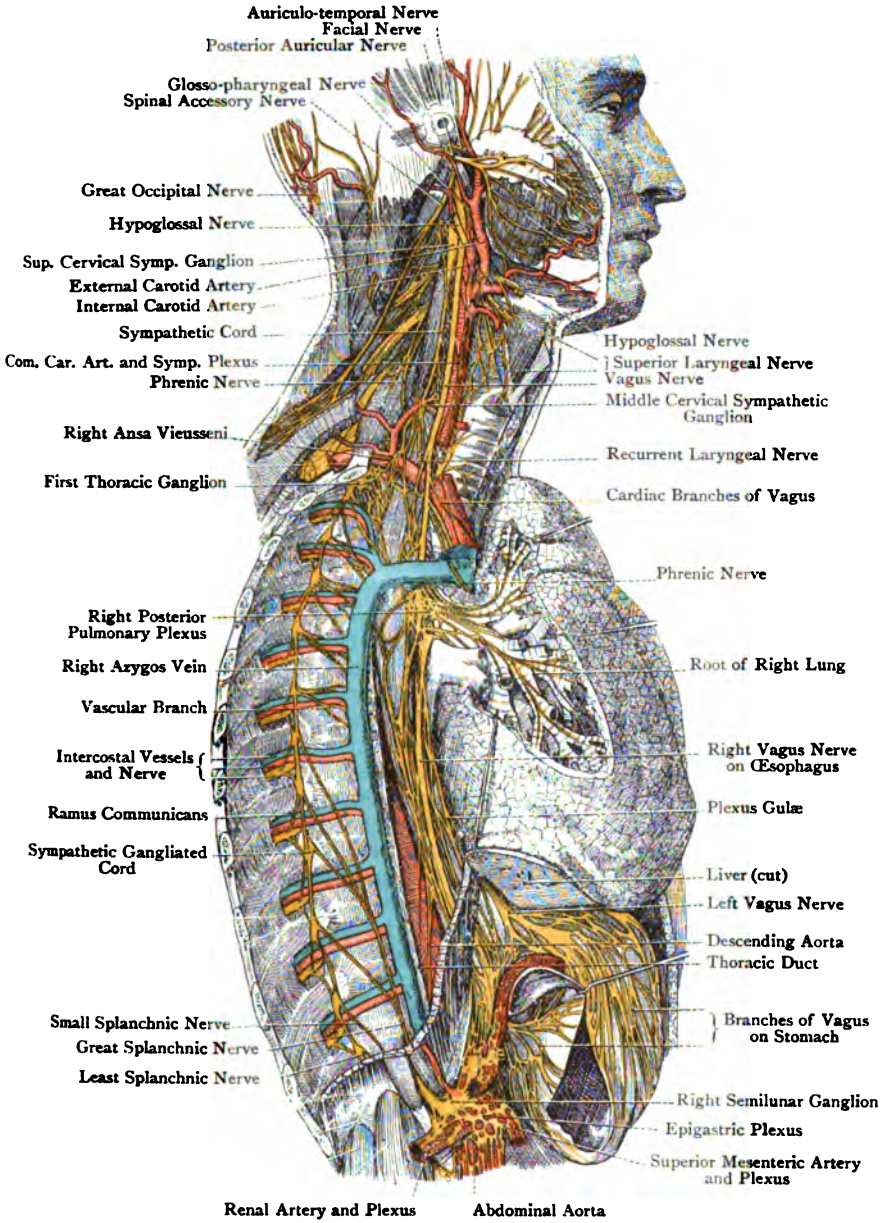

FIG. 483.—NERVES OF THE RIGHT SIDE OF THE FACE, NECK, AND THORAX (HIRSCHFELD AND LEVEILLÉ).

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Summary of the Glosso-pharyngeal Nerve—1. **Cutaneous Distribution.**—It supplies (*a*) the mucous membrane of the tympanum, the posterior third of the tongue, the pillars of the fauces, and the pharynx; and (*b*) the tonsil. 2. **Muscular Distribution.**—It supplies the stylo-pharyngeus. 3. **Glandular Distribution.**—Through means of (1) its tympanic, subsequently small superficial petrosal, branch, (2) the otic ganglion, and (3) the auriculo-temporal nerve, it furnishes secretory branches to the parotid gland.

The Pneumogastric Nerve.

The pneumogastric (vagus) or tenth cranial nerve is a mixed nerve, consisting of both afferent and efferent fibres. It emerges from the cranial cavity through the middle compartment of the jugular foramen, being enclosed in the same sheath of dura mater as the spinal accessory, and, with that nerve, lying on the inner side of, and slightly posterior to, the glosso-pharyngeal. In the foramen it presents a small enlargement, called the ganglion of the root. After emerging from the foramen, it is joined by the accessory portion of the spinal accessory nerve, and it here presents another enlargement, called the ganglion of the trunk. This ganglion is larger and longer than that of the root, measuring fully $\frac{3}{4}$ inch in length, and presenting a somewhat plexiform appearance. In this part of its course the nerve lies between the internal carotid artery and the internal jugular vein, the glosso-pharyngeal nerve being in front of it, and the spinal accessory behind it. The hypoglossal nerve lies at first deeply behind it, but subsequently turns round the outer side of the ganglion of the trunk. The pneumogastric then descends within the carotid sheath, lying at first between the internal carotid artery and the internal jugular vein, and then between the common carotid artery and the internal jugular vein, being on a plane posterior to both vessels. Within the sheath the nerve occupies a special compartment, situated in the back part of the septum which separates the artery from the vein. Beyond the root of the neck the right and left nerves present important differences in their course and relations (see p. 907).

Branches—A. **Ganglion of the Root**—1. **Branches of Communication.**—(*a*) It receives two filaments from the bulbar or accessory portion of the spinal accessory nerve. (*b*) It communicates by a small twig with the petrous ganglion of the glosso-pharyngeal nerve. (*c*) It communicates with the facial, and with the posterior auricular branch of the facial, through means of its auricular branch of distribution (Arnold's nerve). (*d*) It receives a twig from the superior cervical ganglion of the sympathetic.

2. **Branches of Distribution.**—(*a*) The *meningeal branch* takes a recurrent course, and, after entering the cranial cavity, supplies the dura mater which lines the cerebellar fossa of the occipital bone. (*b*) The *auricular branch*, or *nerve of Arnold*, is of small size, and is soon reinforced by a twig from the petrous ganglion of the glosso-pharyngeal. It enters the auricular canaliculus through an aperture on the posterior part of the outer wall of the jugular fossa. In this

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canaliculus it traverses the petrous portion of the temporal bone, crossing in its course the inner aspect of the descending portion of the aqueduct of Fallopius a little above the stylo-mastoid foramen, where it forms its first communication with the facial nerve. It then emerges from the *pars petrosa* through the auricular or tympano-mastoid fissure, between the mastoid process and the tympanic plate, and thereafter divides into two branches. One of these joins the posterior auricular branch of the facial nerve, and the other is distributed to (*a*) the skin of the inner surface of the auricle, and (*b*) the skin of the lower and back part of the external auditory meatus.

B. **Ganglion of the Trunk**—1. **Branches of Communication.**—(*a*) The most important branch of communication is the *bulbar* or *accessory portion of the spinal accessory nerve*, which passes over the surface of the ganglion in intimate contact with it. Most of the bulbar fibres are continued into the pharyngeal and superior laryngeal nerves, but some of them descend in the main trunk of the pneumogastric, and pass into its cardiac and inferior laryngeal branches. The bulbar fibres are to be regarded as of two kinds, namely, *motor*, for the muscles of the soft palate, pharynx, and larynx, and *cardiac inhibitory*. (*b*) Branches pass between the ganglion of the trunk and the hypoglossal nerve. (*c*) A communicating branch is received from the superior cervical ganglion of the sympathetic.

2. **Branches of Distribution.**—These are two in number, namely, pharyngeal and superior laryngeal.

The **pharyngeal nerve** arises from the upper part of the ganglion of the trunk, its fibres being chiefly derived from the bulbar or accessory portion of the spinal accessory nerve. It passes forwards and downwards over the internal carotid artery, and divides into branches opposite the middle constrictor muscle, which join the pharyngeal branches of the glosso-pharyngeal and superior cervical ganglion of the sympathetic to form the pharyngeal plexus.

The **pharyngeal plexus** is situated upon the middle constrictor muscle of the pharynx. It is formed by (1) the pharyngeal branch of the ganglion of the trunk of the pneumogastric; (2) the pharyngeal branches of the glosso-pharyngeal; and (3) the pharyngeal branches of the superior cervical ganglion of the sympathetic.

Branches.—These are distributed to (1) the constrictor muscles of the pharynx; (2) the mucous membrane of the pharynx; and (3) the palato-glossus, palato-pharyngeus, levator palati, and azygos uvulæ muscles. Branches of communication pass between the plexus and the superior laryngeal and external laryngeal nerves, and another branch, known as the *lingual branch of the vagus*, passes to the hypoglossal nerve.

Superior Laryngeal Nerve.—This nerve, which is principally sensory, arises from the ganglion of the trunk of the pneumogastric near its centre, and contains fibres of the bulbar or accessory portion of the spinal accessory nerve. It passes downwards and

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forwards behind the internal carotid artery, having previously received communicating branches from the superior cervical ganglion of the sympathetic and from the pharyngeal plexus. As it passes behind the internal carotid artery, it divides into two branches, internal and external. The **internal laryngeal nerve,** which is sensory, passes forwards, in company with the superior laryngeal branch of the superior thyroid artery, to the thyro-hyoid membrane, which it pierces under cover of the posterior border of the thyro-hyoid muscle. Having reached the interior of the larynx, it divides into branches which supply the mucous membrane of the epiglottis, with its folds, the mucous membrane of the larynx as low as the true vocal cords, and that covering the lateral and posterior portions of the cricoid cartilage. One branch descends over the inner surface of the ala of the thyroid cartilage, and joins a branch of the inferior or recurrent laryngeal. The **external laryngeal nerve,** of small size, descends beneath the sterno-thyroid muscle to the crico-thyroid muscle, which it supplies. It furnishes some twigs to the inferior constrictor, and a filament which joins the superior cardiac branch of the sympathetic. It receives a communicating branch from the superior cervical ganglion of the sympathetic, and one or two branches from the pharyngeal plexus.

Inferior or Recurrent Laryngeal Nerve.—This nerve is mainly motor, and is the principal motor nerve of the intrinsic muscles of the larynx. It contains fibres of the bulbar or accessory portion of the spinal accessory nerve. The *right* nerve arises from the pneumogastric at the root of the neck in front of the first part of the subclavian artery, round the lower border of which it bends, and then ascends behind it. Thereafter it passes upwards and inwards behind the carotid sheath and inferior thyroid artery to the groove between the trachea and the œsophagus. The *left* nerve arises in the thorax from the pneumogastric in front of the arch of the aorta, on a level with its lower border. It passes backwards within the arch at the place of attachment of the ligamentum ductûs arteriosi, and then it turns upwards behind the arch. Having reached the groove between the trachea and the œsophagus, it ascends therein to the neck. The right and left nerves pass upwards in the groove between the trachea and the œsophagus, on each side, lying behind the corresponding inferior thyroid artery. At the level of the cricoid cartilage each nerve passes beneath the lower border of the inferior constrictor muscle, and enters the larynx behind the crico-thyroid joint.

Extralaryngeal Branches.—(1) *Communicating twigs* pass between the recurrent laryngeal nerve and the inferior cervical ganglion of the sympathetic ; (2) *cardiac branches,* which contain bulbar fibres from the spinal accessory, are furnished to the deep cardiac plexus ; (3) *tracheal* and *œsophagcal branches* are supplied to these tubes ; and (4) *muscular offsets* pass to the lower part of the inferior constrictor.

Intralaryngeal Branches.—These are chiefly *muscular,* and supply

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the intrinsic muscles of the larynx, except the crico-thyroid, which is supplied by the external laryngeal nerve. *Sensory branches*, however, are given to the laryngeal mucous membrane below the true vocal cords, except over the lateral and posterior portions of the cricoid cartilage. Within the larynx the nerve communicates with a branch of the internal laryngeal nerve, under cover of the lower part of the ala of the thyroid cartilage.

For the explanation of the recurrent course of each inferior laryngeal nerve, see p. 903.

Cervical Cardiac Branches.—These are subject to variation as regards numbers. As a rule, there are two, upper and lower, both of which contain bulbar fibres from the spinal accessory. Those of the right side pass behind the first part of the subclavian artery, and end in the *deep* cardiac plexus. On the left side the **upper** nerve passes to the *deep* cardiac plexus, but the **lower** nerve terminates in the *superficial* cardiac plexus.

Summary of the Pneumogastric Nerve in the Neck—1. **Motor Distribution.**—The nerve supplies (1) the muscles of the soft palate, except the tensor palati; (2) the constrictor muscles of the pharynx; (3) the intrinsic muscles of the larynx; and (4) the muscular tissue of the œsophagus and trachea. 2. **Sensory Distribution.**—It supplies (1) the pharynx, œsophagus, and trachea; (2) a limited portion of the dura mater; and (3) a small portion of the skin on the inner surface of the auricle, as well as of the lower and back part of the external auditory meatus. 3. **Communications.**—Each pneumogastric nerve forms connections with the facial, glosso-pharyngeal, spinal accessory, hypoglossal, and sympathetic nerves. It is also connected with the loop between the first and second cervical spinal nerves. Its most important connection is that which is established with the bulbar or accessory portion of the spinal accessory nerve. The bulbar fibres of the nerve are probably chiefly concerned in the innervation of the muscles of the soft palate (except the tensor palati), pharynx, and larynx, but also to a certain extent in the innervation of the heart.

Spinal Accessory Nerve.

The spinal accessory or eleventh cranial nerve consists of two parts, bulbar or accessory, and spinal. In the jugular foramen these two parts either unite to form one trunk, or freely intermingle, and a communication is established between the accessory part and the ganglion of the root of the pneumogastric by means of two twigs. The nerve emerges through the jugular foramen, being enclosed in the same sheath of dura mater as the pneumogastric, behind which it lies. Immediately beneath the jugular foramen the two parts of the nerve separate from each other.

The **bulbar** or **accessory part** passes over, but in intimate contact with, the ganglion of the trunk of the pneumogastric, and its fibres are continued partly into the pharyngeal and superior laryngeal branches of the ganglion of the trunk, and partly into the trunk of the vagus below the ganglion. These latter fibres are ultimately prolonged into the cardiac and recurrent laryngeal branches of the nerve. The bulbar or accessory fibres of the spinal accessory are regarded as (1) the motor nerves of (*a*) the muscles of the soft

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palate, except the tensor palati, (*b*) the constrictor muscles of the pharynx, and (*c*) the intrinsic muscles of the larynx; and (2) the inhibitory fibres of the heart.

The **spinal part** of the spinal accessory nerve passes backwards and downwards either behind or in front of the internal jugular

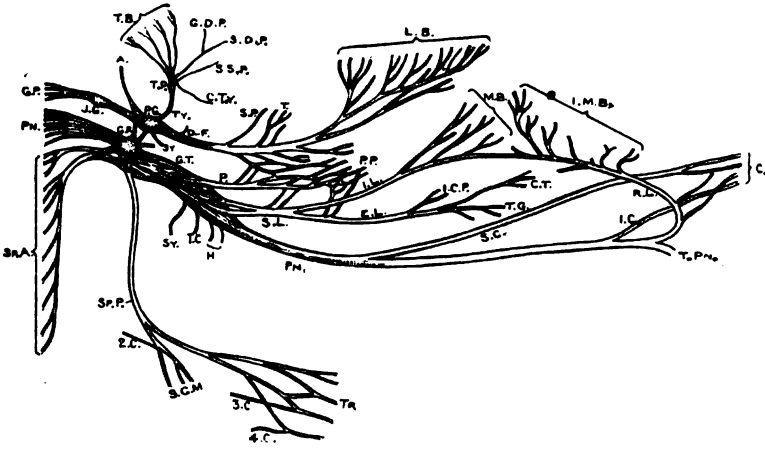

FIG. 484.—SCHEME OF THE GLOSSO-PHARYNGEAL, PNEUMOGASTRIC, AND SPINAL ACCESSORY NERVES (FLOWER).

G.P. Glosso-Pharyngeal.

J.G. Jugular Ganglion
P.G. Petrous Ganglion
Tv. Tympanic Branch (Jacobson's Nerve)
C.Tv. Carotico-tympanic Nerve
T.P. Tympanic Plexus
T.B. Branches to Tympanum
S.S.P. Small Superficial Petrosal
S.D.P. Small Deep Petrosal
G.D.P. Branch to Great Deep Petrosal
Sy. Communicating from Sympathetic
D.F. Twig from Digastric Branch of Facial
S.P. Branch to Stylo-pharyngeus Muscle
T. Tonsillar Branches
L.B. Lingual Branches

PN. Pneumogastric.

G.R. Ganglion of Root
A. Auricular Branch (Arnold's Nerve)
G.T. Ganglion of Trunk
Sy. Communicating from Sympathetic
1c. Branch from First Cervical
H. Communicating with Hypoglossal
P. Pharyngeal Branch
P.P. Pharyngeal Plexus
S.L. Superior Laryngeal
I.L. Internal Laryngeal
M.B. Branches to Mucous Membrane of Larynx
E.L. External Laryngeal
I.C.P. Branch to Inferior Constrictor Muscle
T.G. Branches to Thyroid Body
C.T. Branch to Crico-thyroid Muscle
S.C. Superior Cardiac Branch
I.C. Inferior Cardiac Branch
R.L. Recurrent Laryngeal
I.M.B. Branches to Intrinsic Laryngeal Muscles (except Crico-thyroid)
C.P. To Cardiac Plexus
T.PN. Thoracic Pneumogastric

SP.A. Spinal Accessory.

SP.P. Spinal Portion of Spinal Accessory
2c. From Second Cervical
S.C.M. To Sterno-cleido-mastoid
3c. From Third Cervical
4c. From Fourth Cervical
TR. To Trapezius

vein. It then pierces the deep surface of the sterno-cleido-mastoid, which it supplies along with a branch of the second cervical nerve. Thereafter it crosses the posterior triangle of the neck obliquely downwards and backwards to the anterior border of the trapezius, beneath which it passes, supplying the muscle, in company with branches from the third and fourth cervical nerves.

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Summary.—The **spinal portion** of the spinal accessory nerve supplies two muscles, namely, the trapezius and the sterno-cleido-mastoid. The **bulbar portion,** through its connection with the pneumogastric nerve and its branches, supplies (1) the muscles of the soft palate, except the tensor palati; (2) the constrictor muscles of the pharynx; and (3) the intrinsic muscles of the larynx. It also furnishes the *inhibitory fibres* of the heart, which reach that organ through the cardiac branches of the pneumogastric.

Hypoglossal Nerve.

The hypoglossal or twelfth cranial nerve consists at first of two bundles, which pierce the dura mater separately. In passing through the anterior condylar foramen these two bundles unite to form one trunk. After emerging from that foramen the nerve lies deeply under cover of the internal carotid artery and internal jugular vein. It then turns round the outer side of the ganglion of the trunk of the pneumogastric, with which it is closely connected, and passes forwards between the internal carotid artery and internal jugular vein. Thereafter it descends to the lower border of the posterior belly of the digastric, at which level it hooks round the occipital artery from without inwards, and crosses in front of the external carotid artery and its lingual branch. In this part of its course the nerve lies in the superior carotid triangle. It next courses forwards above the hyoid bone, passing beneath the tendon of the digastric and the lower part of the stylo-hyoid muscle, and resting on the hyo-glossus. Thereafter it disappears beneath the mylo-hyoid, still resting upon the hyo-glossus, where it is accompanied by the ranine vein, and lies below the deep part of the submaxillary gland. At the anterior border of the hyo-glossus it is connected with the lingual nerve, and then enters the genio-hyo-glossus.

Branches—1. **Of Communication.**—After emerging from the anterior condylar foramen, the hypoglossal nerve communicates with the ganglion of the trunk of the pneumogastric. It then receives a branch from the superior cervical ganglion of the sympathetic, and one from the first cervical nerve, or the loop between the first and second. As it hooks round the occipital artery, it receives the lingual branch of the vagus from the pharyngeal plexus; and at the anterior border of the hyo-glossus it is connected with the lingual nerve.

2. **Of Distribution.**—One or two *meningeal branches* arise from the nerve in the anterior condylar foramen, which take a recurrent course, and enter the cranial cavity to supply the dura mater in the vicinity of the foramen.

The *descendens cervicis* (descendens hypoglossi) nerve has been already described (see p. 1032).

The *thyro-hyoid nerve* will be found described on p. 1033.

The *muscular branches* are given off from the nerve as it lies upon the hyo-glossus under cover of the mylo-hyoid. These supply the stylo-glossus, hyo-glossus, genio-hyo-glossus, and genio-hyoid. The

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nerve to the genio-hyoid is generally regarded as being composed of spinal fibres, derived from the first, second, and third cervical nerves.

The *terminal* or *glossal branches* pierce the under surface of the tongue, and are distributed to its muscular tissue.

The hypoglossal nerve receives many spinal fibres. Those derived from the first cervical nerve, or the loop between the first and second, soon become applied to it, and the most of them pass off to form the descendens cervicis nerve. A few of these, however, still pass along the main trunk. The spinal fibres derived from the second and third cervical nerves in part ascend in the descendens cervicis nerve, and then pass off from it to be applied to the main trunk in its onward course.

Summary—1. **Distribution.**—The hypoglossal fibres of the nerve supply the stylo-glossus, hyo-glossus, genio-hyo-glossus, and intrinsic muscles of the tongue. The spinal fibres supply both bellies of the omo-hyoid, the sterno-hyoid, sterno-thyroid, thyro-hyoid, and genio-hyoid muscles. The hypoglossal nerve also supplies the dura mater in the vicinity of the cranial aspect of the anterior condylar foramen. 2. **Connections.**—It establishes connections with (1) the ganglion of the trunk of the vagus; (2) the superior cervical ganglion of the sympathetic; (3) the first, second, and third cervical nerves; (4) the pharyngeal plexus, through means of the lingual branch of the vagus; and (5) the lingual nerve from the inferior maxillary division of the fifth cranial nerve.

Gangliated Cord of the Sympathetic.

Cervical Portion.—This portion of the sympathetic cord extends from the base of the skull, at the foramen caroticum on the under surface of the petrous part of the temporal bone, to the root of the neck, where it enters the thorax, passing, on the right side, behind the subclavian artery. It lies directly behind the carotid sheath, and in front of the transverse processes of the cervical vertebræ, resting upon the rectus capitis anticus major and longus colli muscles. The cord presents three ganglia—superior, middle, and inferior.

Superior Cervical Ganglion.—This ganglion is elongated and fusiform. It is regarded as representing four ganglia united into one, and corresponding to the first four cervical nerves. It is situated in front of the transverse processes of the second and third cervical vertebræ, and lies upon the rectus capitis anticus major, the pneumogastric nerve being external to it. At either end it tapers, being continued superiorly into its ascending branch, and inferiorly into the descending cord.

Branches.—These are numerous and complicated. They may be conveniently arranged into ascending, external or communicating, internal or pharyngeal, superior cardiac, and anterior or vascular.

The **ascending branch** enters the carotid canal in the petrous part of the temporal bone, in company with the internal carotid artery.

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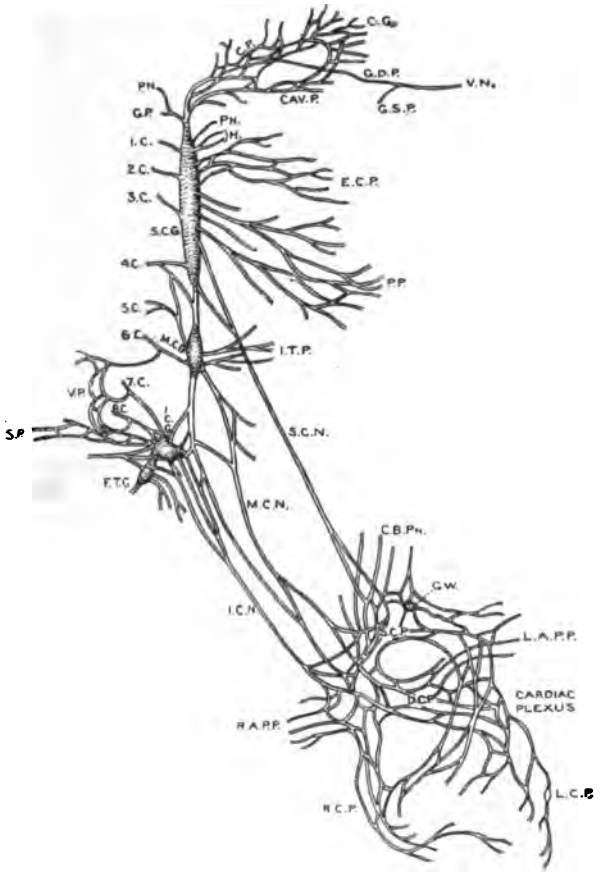

FIG. 485.—SCHEME OF THE SYMPATHETIC NERVE IN THE NECK, AND OF THE CARDIAC PLEXUS (FLOWER).

S.C.G. Superior Cervical Ganglion.

P.N. and G.P. Branches to Pneumogastric and Glosso-pharyngeal
1c, 2c, 3c, 4c. Branches to Upper Four Cervical Nerves
C.P. Carotid Plexus
Cav. P. Cavernous Plexus
C.G. Branch to Ciliary Ganglion
G.D.P. Great Deep Petrosal
G.S.P. Great Superficial Petrosal
V.N. Vidian Nerve
P.N. To Ganglion of Trunk of Pneumogastric
H. To Hypoglossal
E.C.P. To External Carotid Plexus
P.P. To Pharyngeal Plexus
S.C.N. Superior Cardiac Nerve

M.C.G. Middle Cervical Ganglion.

5c, 6c. To Fifth and Sixth Cervical Nerves
I.T.P. To Inferior Thyroid Plexus
M.C.N. Middle Cardiac Nerve

I.C.G. Inferior Cervical Ganglion.

7c, 8c. To Seventh and Eighth Cervical Nerves
V.P. To Vertebral Plexus
S.P. To Subclavian Plexus
I.C.N. Inferior Cardiac Nerve

F.T.G. First Thoracic Ganglion

Cardiac Plexus.

C.B.PN. Cardiac Branches of Pneumogastric
S.C.P. Superficial Cardiac Plexus
G.W. Ganglion of Wrisberg
D.C.P. Deep Cardiac Plexus
R.A.P.P. Right Anterior Pulmonary Plexus
L.A.P.P. Left Anterior Pulmonary Plexus
R.C.P. Right Coronary Plexus
L.C.P. Left Coronary Plexus

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and divides into two parts. The *external division* lies upon the outer side of the artery, and its subdivisions form by their interlacement the **carotid plexus.** From this plexus several communicating branches are given off. (1) The carotico-tympanic nerve enters the tympanum, and joins the tympanic branch (Jacobson's nerve) of the glosso-pharyngeal, to take part in the tympanic plexus. (2) The great deep petrosal nerve joins the great superficial petrosal from the geniculate ganglion of the facial, in the upper part of the foramen lacerum medium, to form the Vidian nerve, which passes through the Vidian canal to join Meckel's ganglion. (3) A branch (or branches) passes to join the sixth cranial nerve. (4) One or more branches pass to join the Gasserian ganglion. The carotid plexus furnishes filaments to the coats of the internal carotid artery, and it receives the small deep petrosal nerve from the tympanic plexus.

The *internal division* of the ascending branch of the superior cervical ganglion lies upon the inner side of the internal carotid artery, to which it furnishes twigs, and its subdivisions form by their interlacement the **cavernous plexus.** This plexus lies in contact with the internal carotid artery as it traverses the cavernous sinus. Its communicating branches pass to join the third, fourth, and ophthalmic division of the fifth cranial nerves, and the ciliary or lenticular ganglion. The last-named branch forms the sympathetic root of the ciliary ganglion, and enters the orbit through the sphenoidal fissure. It is the source of the motor supply of the dilator pupillæ muscle. The cavernous plexus furnishes filaments to the coats of the internal carotid artery, and offsets which accompany the branches of that artery, around which they are disposed as plexuses.

The **external branches** are communicating, and pass to (1) each of the upper four cervical nerves; (2) the petrosal ganglion of the glosso-pharyngeal; (3) the ganglion of the root, and the ganglion of the trunk, of the vagus; and (4) the hypoglossal nerve.

The **internal branches** are pharyngeal and cardiac. The **pharyngeal branches,** two or three in number, unite with the pharyngeal branches of the glosso-pharyngeal and vagus to form the pharyngeal plexus (see p. 1149).

The **superior cardiac nerve** arises by two roots from the lower part of the superior cervical ganglion, and descends behind the carotid sheath, lying internal to the main sympathetic cord. The nerve of the right side passes either over or beneath the first part of the subclavian artery, and then along the innominate artery, to terminate in the *deep* cardiac plexus. In its course down the neck it receives twigs from the external laryngeal nerve, and is joined by the upper cervical cardiac branch of the pneumogastric nerve. As it enters the thorax, it receives a filament from the recurrent laryngeal nerve. The nerve of the left side within the thorax accompanies the left common carotid artery, and passes over the arch of the aorta to terminate in the *superficial* cardiac plexus.

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The **anterior branches** are vascular, and pass to the external carotid artery, upon which and its branches they form delicate plexuses.

Middle Cervical Ganglion.—This ganglion is situated opposite the sixth cervical vertebra, and usually lies close to the inferior thyroid artery. It is the smallest of the three, and probably represents two ganglia united into one. Occasionally it is absent. It is connected by grey rami with the fifth and sixth cervical nerves, and its branches of distribution are thyroid and middle cardiac. The **thyroid branches** accompany the inferior thyroid artery to the thyroid body, and they communicate with the external and recurrent laryngeal nerves. The **middle cardiac nerve** of each side terminates in the *deep* cardiac plexus. The nerve of the right side passes either in front of, or behind, the first part of the right subclavian artery. It then descends in front of the trachea, and joins the right half of the deep cardiac plexus. The nerve of the left side enters the thorax between the left common carotid and left subclavian arteries, and it joins the left half of the deep cardiac plexus.

Inferior Cervical Ganglion.—This ganglion is situated between the transverse process of the seventh cervical vertebra and the neck of the first rib, where it lies behind the root of the vertebral artery. It is intermediate in size between the superior and middle ganglia, and, like the middle, it probably represents two ganglia united into one. It is frequently fused with the first thoracic ganglion. One or two cords establish a communication between it and the middle cervical ganglion, passing in front of the first part of the subclavian artery. The cord or cords in front of the vessel form a loop around it, called the **ansa Vieussenii,** or *ansa subclavia*. The inferior cervical ganglion is connected by grey rami with the seventh and eighth cervical nerves, and its branches of distribution are vascular and inferior cardiac. The **vascular branches** accompany the vertebral artery in the form of the *vertebral plexus*, which gives filaments to the vessel and offshoots along its various branches. The plexus is continued along the basilar artery and its branches, and on to the posterior cerebral arteries. The **inferior cardiac nerve** on each side joins the *deep* cardiac plexus. The nerve of the right side passes behind the first part of the right subclavian artery, and then in front of the trachea. It is connected with the middle cardiac and recurrent laryngeal nerves. The nerve of the left side in many cases joins the middle cardiac nerve, and so reaches the deep cardiac plexus.

Constitution of the Cervical Sympathetic Cord.

The sympathetic cord in the neck contains the following important groups of fibres, namely, (1) dilator pupillæ, (2) vaso-constrictor and vaso-dilator, (3) secretory, and (4) accelerator.

The **dilator pupillæ fibres** are derived from the *upper three thoracic nerves*, and ascend in the sympathetic cord to the superior cervical ganglion, in which they terminate. From this ganglion they are continued as sympathetic

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fibres to the cavernous plexus, through this plexus to the ciliary ganglion, and thence to the dilator pupillæ muscle.

The **vaso-constrictor fibres** are derived from a variable number of thoracic nerves, commencing at the second and terminating at the eighth. The origin of the **vaso-dilator fibres** is not definitely known. The vaso-constrictor fibres ascend to the superior cervical ganglion, in which they terminate. From this ganglion they are continued as sympathetic fibres into the plexus around the external carotid artery, and thence along the branches of that vessel.

The **secretory fibres** are destined for the submaxillary gland, and are derived chiefly from the second and third thoracic nerves. They also ascend to the superior cervical ganglion, in which they terminate. They are thence continued as sympathetic fibres into the external carotid plexus, from that into the facial plexus, and thence into the submaxillary ganglion, from which they pass into the submaxillary gland.

The **accelerator fibres of the heart** are chiefly derived from the second and third thoracic nerves, but some also spring from the first, fourth, and fifth nerves. The spinal fibres pass to the middle and lower cervical ganglia, from each of which they are continued as sympathetic fibres.

The Mouth.

The mouth, or buccal cavity, extends from the *rima oris* in front, where it opens externally on the face, to the isthmus faucium behind, where it opens into the pharynx. It is divided by the upper and lower dental arches into two compartments, the anterior of which is called the vestibule and the posterior the mouth proper.

The **vestibule** is bounded anteriorly and externally by the lips and cheeks, and internally by the dental arches and gums. Superiorly and inferiorly it is bounded by the reflection of the mucous membrane from the lips and cheeks on to the gums. In the median line, above and below, the mucous membrane forms a small vertical fold, called the *frenulum labii*. On the inner surface of each cheek the vestibular mucous membrane presents a small papilla opposite the second upper molar tooth, and on this is the minute opening of Stensen's duct.

The **mouth proper** lies within the dental arches. It communicates with the vestibule by the interval between the upper and lower teeth, and also by an opening at either side situated behind the last molar tooth. Anteriorly and externally it is bounded by the dental arches and gums, and posteriorly it opens into the pharynx by means of the isthmus faucium. The *roof*, which is arched, is formed by the hard palate and the velum pendulum palati, or soft palate. The *floor* is formed by the tongue, and the reflection of mucous membrane from the inner surface of the lower dental arch on to its under surface. In the region of the tip of the tongue the lateral reflections of mucous membrane from the two sides of the lower dental arch are continuous across the median line. In the median line the mucous membrane forms a prominent fold, called the *frenum linguæ*, which is connected above with the under surface of the tongue a little distance from the tip. In some children it may extend quite to the tip, impairing the utility of the organ, and giving rise to the condition known as 'tongue-tied.' Close to

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each side of the frenum there is a small papilla, on which is the opening of Wharton's duct, and near to this is the opening of the duct of Rivini or of Bartholin, which comes from the outermost lobule of the sublingual gland. A little posterior to this is a fold of the mucous membrane, at either side, produced by the upper border of the subjacent sublingual gland. This fold is known as the *plica sublingualis*, and it extends from the side of the tongue to the dental arch. It is upon this plica that the majority of the ducts of Walther (sublingual ducts) open.

The **lips** are covered by skin externally, and mucous membrane internally. Between these two layers are the muscular fibres

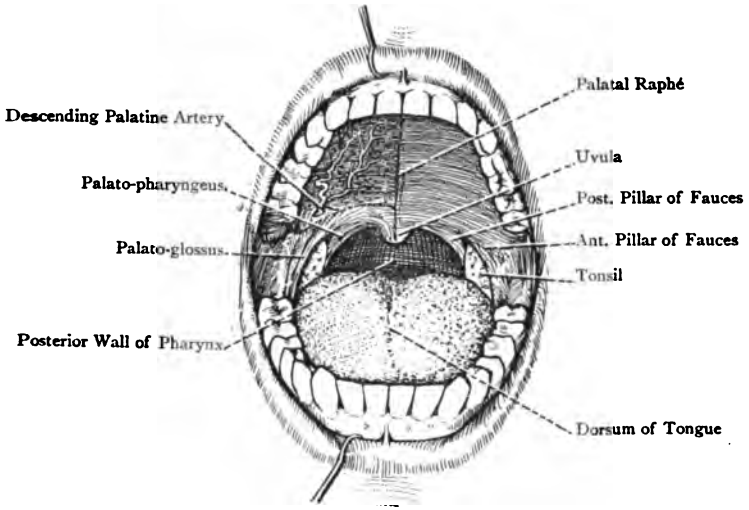

FIG. 486.—THE BUCCAL CAVITY AND ISTHMUS FAUCIUM.

The Maxillæ are widely separated.

of the orbicularis oris, blended with which are the fibres of the buccinator, and, in the case of the upper lip, fibres of the depressor anguli oris, whilst in the case of the lower lip there are the fibres of the levator anguli oris. Between the mucous membrane and the muscular element there are a number of small racemose glands, called the labial glands, the ducts of which open on the inner surface of each lip. The tortuous coronary arteries are embedded in each lip, and those of opposite sides anastomose at the median line.

The **cheeks** are covered externally by skin, and internally are lined with mucous membrane. The muscular element consists of the buccinator, which is covered by the buccal fascia. Posteriorly this fascia is continuous with the pharyngeal fascia, which is derived from the deep cervical fascia, the two being known as the

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bucco-pharyngeal fascia. Superiorly and inferiorly it is attached to the dental arches.

The **buccal pad of fat** is situated upon the buccal fascia, and is well developed in young children. It is of soft consistence, and is continuous with the fat beneath the temporal muscle under cover of the ramus of the lower jaw.

The buccal fascia, buccinator, and lining mucous membrane are pierced by Stensen's duct. Between the buccinator and the mucous membrane there are several racemose buccal glands. In addition to these there are three or four molar glands, mucous in character, which are situated superficial to the buccal fascia in the angle between the masseter and buccinator.

The **masseteric fascia** is an upward prolongation of the deep cervical fascia. It is attached superiorly to the zygoma, and externally is continuous with the parotid fascia.

The **dental arches** are formed by the alveolar borders of the superior and inferior maxillæ, the teeth, and the gums.

The **mucous membrane of the gums** is separated from the subjacent periosteum by dense connective tissue, which connects the two in such a close manner that the mucous membrane is immovable. Close to the necks of the teeth it is beset with papillæ. The **mucous membrane of the hard palate,** like that of the gums, is separated from the periosteum by a thick layer of dense connective tissue, which binds the two so closely that the mucous membrane is immovable. It presents a median raphé, which is continued over the soft palate, and ends in front at the anterior palatine fossa in a small papillary elevation, known as the *incisor papilla.* On either side of the raphé anteriorly there are a few transverse rugæ. Each lateral half of the hard palate is traversed by the ramifications of the descending palatine artery, the branches of which extend forwards and inwards from either lateral angle posteriorly. The mucous membrane of the hard palate is provided with racemose palatal glands of a serous character, which are arranged in two symmetrical groups laterally disposed.

Nerves.—The **great** or **anterior palatine nerve** descends in the posterior palatine canal, from which it emerges through the posterior palatine foramen. Thereafter it divides into branches which pass forwards in grooves on the hard palate, and supply the mucous membrane, glands, and inner aspect of the upper gum. The **naso-palatine nerve** is distributed to the mucous membrane behind the incisor teeth, where it communicates with twigs of the great or anterior palatine nerve. To reach the hard palate the nerve of the right side passes through the *posterior foramen* of Scarpa, whilst the left nerve passes through the *anterior* foramen. The mucous membrane of the cheek is supplied by the long buccal nerve, which is a branch of the inferior maxillary division of the fifth cranial nerve. The mucous membrane of the floor of the mouth derives its nerves from the submaxillary ganglion.

Arteries.—These are the right and left descending palatine

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branches of the third part of the internal maxillary. Each descending palatine artery takes the same course as, and has a similar distribution to, the great or anterior palatine nerve. At the anterior palatine fossa it terminates in a small branch which ascends through Stensen's canal, and anastomoses at the upper end of that canal with the naso-palatine branch of the spheno-palatine artery.

Development of the Mouth and Nasal Cavities.—The **stomatodæum (stomodæum)**, or primitive mouth, makes its appearance as a depression of the epiblast on the ventral wall of the fore-gut between the fore-brain and the pericardial region. This epiblast comes into contact with the hypoblast of the fore-gut, and the bilaminar structure so formed is known as the **bucco-pharyngeal septum,** or **oral plate.** When this septum ruptures the stomatodæum is formed, and the fore-gut now opens externally. At a later period the stomatodæum becomes bounded on either side by the first or mandibular arch, and above by the fronto-nasal process. Subsequently the two mandibular arches, coming together, fuse, and form the lower boundary of the stomatodæum. Thereafter the formation of the lower and upper dental arches, the roof of the mouth, and the nasal cavities takes place.

From the stomatodæum are developed the epithelium of the vestibular portion of the mouth, gums, salivary glands, and the greater part of that of the nasal cavities, as well as the anterior lobe of the pituitary body.

Each half of the inferior maxilla or mandible, as stated in the section of Osteology (p. 151), is formed chiefly from the fibrous tissue which surrounds a portion of Meckel's cartilage, this being the bar of cartilage which forms the skeletal framework of the mandibular arch ; but the symphysial part of the mandible is developed from the mesial end of Meckel's cartilage.

The mandibular process of each mandibular arch grows forwards between the eye and the mouth, and it gives rise to the chief part of the superior maxilla, including the greater portion of one half of the hard palate. The part of the hard palate which is formed by the palate bone is developed from the pterygo-palatine bar of cartilage within the maxillary process. The premaxillary part of the hard palate on either side is developed from the globular process, which belongs to the mesial nasal process of the fronto-nasal process.

By the formation of the hard palate on either side, the stomatodæum becomes divided into two compartments, namely, a lower, which represents the permanent mouth, and an upper, which represents the nasal cavity, at this period single. This single cavity becomes subsequently divided into the two nasal chambers by the growth of the nasal septum (see pp. 150 and 151).

For the formation of the lateral wall of each nasal chamber, see p. 151.

For some time a wide communication exists between the mouth and nasal chambers anteriorly. It is situated between the parts of the hard palate which are developed from the maxillary and globular processes. This, however, becomes gradually diminished as the hard palate becomes completed, and eventually it is represented in man on either side by the incisor canal, or canal of Stensen. In certain animals, *e.g.*, ruminantia, a wide communication persists on either side between the anterior part of the hard palate and each nasal chamber, which leads to the organ of Jacobson.

The **olfactory organ** is developed from the **olfactory pits,** which appear as two depressions of the epiblast in the region of the fronto-nasal process. These olfactory pits divide the fronto-nasal process into mesial and lateral nasal processes, and they extend backwards into the roof of the stomatodæum. Each pit is lined with epiblast, which gives rise to the olfactory epithelium, and, in part, to the olfactory bulb.

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The Tongue.

The tongue is a muscular and very sensitive organ, covered by the buccal mucous membrane, and situated on the floor of the mouth. It is concerned in the sense of taste, mastication, deglutition, and speech, and it consists of a root or base, a body, and a tip. The root is attached by muscles to the hyoid bone. The tip is the anterior free extremity, which, in the quiescent state, lies behind the upper incisor teeth. The body presents an upper surface or dorsum, an under surface, and two lateral borders, right and left. The dorsum is convex from before backwards, and presents over its anterior two-thirds a median depression or raphé, on either side of which the surface is convex from side to side. This raphé terminates posteriorly in the foramen cæcum. In this region the dorsum presents a V-shaped groove, known as the *sulcus terminalis*. The point of the V is at the foramen cæcum, and the two limbs pass outwards and forwards to the sides of the tongue, where the anterior pillars of the fauces are connected with it. The sulcus terminalis marks the union of the two portions, anterior and posterior, from which the tongue is developed. The portion behind it, representing one-third, is the basal, lymphoid, or **pharyngeal portion.** It occupies the buccal portion of the pharynx, and overhangs the epiglottis. The portion in front of the sulcus terminalis, representing two-thirds, is known as the **buccal** or **papillary portion.**

Mucous Membrane.—The mucous membrane covering the basal or pharyngeal portion of the tongue is destitute of proper papillæ, but is freely provided with lymphoid follicles similar to those of the tonsils, and with mucous glands. The follicles are ranged upon the walls of crypts, the mouths of which open upon the surface. The mucous membrane in this region forms the **glosso-epiglottidean fold,** or **frenum epiglottidis,** which is mesially placed. On either side of this fold, between it and each pharyngo-epiglottidean fold, there is a pouch or depression, called the **vallecula.** In front of the sulcus terminalis the mucous membrane of the dorsum, borders, and tip of the tongue is freely covered by characteristic papillæ, which, being visible to the naked eye, impart to this part its distinctive appearance. These papillæ bear secondary papillæ, which, however, are concealed by the epithelial covering. The mucous membrane on the under surface of the tongue in the median line forms, near the tip, a vertical fold, called the *frenum linguæ*. A little external to the frenum, on either side, is an indistinct fringed fold, called the *plica fimbriata*. The two plicæ converge as they pass forwards towards the tip, and inside each the outline of the ranine vein may be visible. On either side of the tongue, in the region of the limbs of the sulcus terminalis, the mucous membrane presents a few ridges which represent the papillæ foliatæ of such animals as the rabbit.

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Papillæ.—These are of three kinds, namely, conical, fungiform, and circumvallate, and they are confined to the anterior two-thirds of the organ. The **conical papillæ** are the most numerous, and are arranged in more or less parallel, closely-set rows, directed forwards and outwards from the median line, except towards the tip, where the rows tend to become transverse. On the sides of the tongue they are arranged in vertical parallel rows. In some

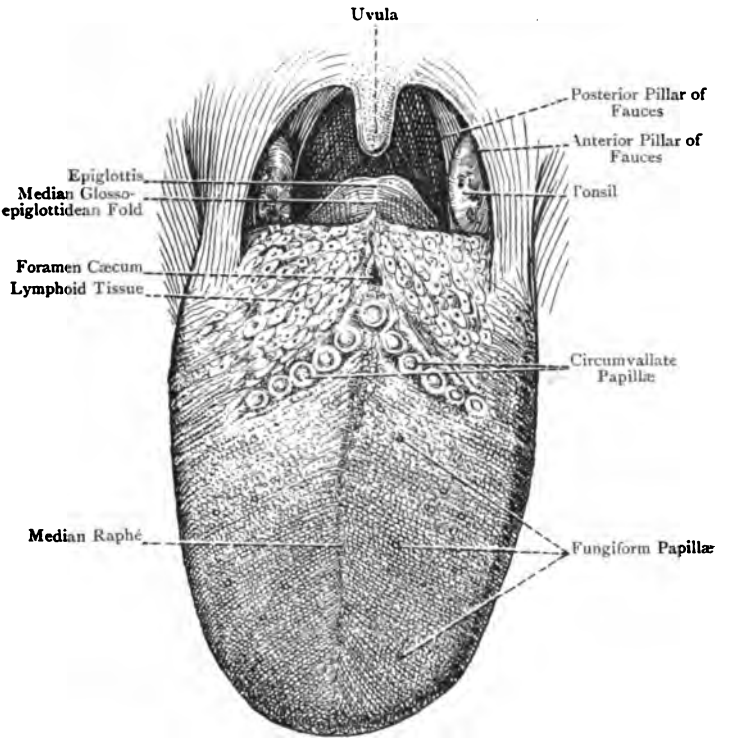

FIG. 487.—THE DORSUM OF THE TONGUE, AND THE FAUCES.

conical papillæ the epithelium which caps the secondary papillæ forms thread-like processes. Such are known as **filiform papillæ.**

The **fungiform papillæ** are scattered amongst the conical, and are most numerous at the sides and tip, being rather sparse over the dorsum. Each is round and enlarged at the surface, but tapers at its deep end, and it bears secondary papillæ, but there is no filiform arrangement of the epithelial caps.

The **circumvallate papillæ** are conspicuous, and vary in number from seven to thirteen. They are arranged in two diverging rows,

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which lie anterior to, and parallel with, the limbs of the sulcus terminalis. The two rows converge backwards and inwards, and so form a capital **V**. In the median line, at the point of the **V**, there is a single circumvallate papilla, behind which is the foramen cæcum. The free surface of each papilla is broad and flat, and bears secondary papillæ, whilst the deep end is somewhat constricted, and is received into a circular pit of the mucosa. In this manner each papilla is surrounded by a space known as the trench. The outer wall of the trench projects slightly beyond the level of the free surface of the papilla, thus forming a circular elevation around it, called the *vallum* (rampart). It is from this circumstance that the papillæ

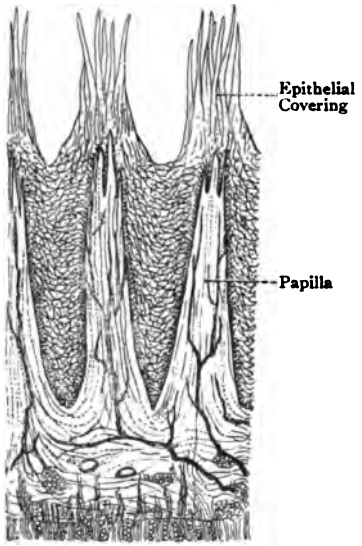

FIG. 488.—THE CONICAL (FILIFORM) PAPILLÆ OF THE TONGUE.

have received the name 'circumvallate.' Their sides, as well as the wall of the vallum, contain the taste-buds.

The tongue contains a number of acinous glands. Some of them open into the trenches around the circumvallate papillæ, where taste-buds are present, and are serous in character, these being known as the **glands of Ebner.** Others open into the foramen cæcum, into the crypts on the posterior third of the dorsum, and along the sides of the organ, these being mucous in character, and being known as the **glands of Weber.** Beneath the apex of the tongue, on either side of the median line, there is a small group of glands, partly serous and partly mucous. These two groups are known as the **glands of Blandin,** or of **Nuhn.**

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The **muscular tissue of the tongue** is of the striped variety. It forms two sets of muscles, namely, extrinsic and intrinsic. The ***extrinsic muscles*** are those which have their origins outside the tongue, and their insertions into it. They are as follows : (1) the genio-hyo-glossus, (2) the hyo-glossus (including the chondro-glossus), (3) the stylo-glossus, and (4) the palato-glossus, all of which have been already described. The ***intrinsic muscles*** are those which are contained entirely within the tongue, and they are arranged in pairs on either side of the median fibrous septum,

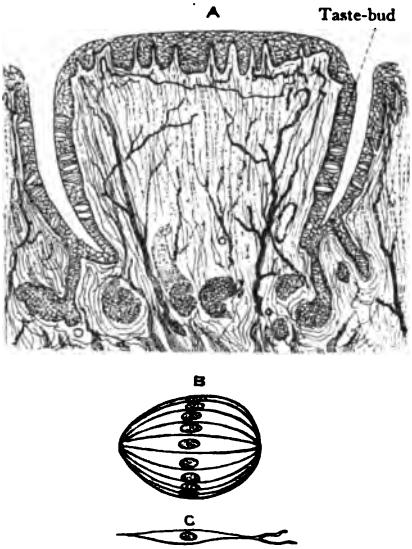

FIG. 489.—VERTICAL SECTION OF A CIRCUMVALLATE PAPILLA OF THE TONGUE.

A, Circumvallate Papilla, beset with Secondary Papillæ ;
B, Taste-bud ; C, Gustatory Cell.

which extends from the tip of the tongue as far back as the body of the hyoid bone. The intrinsic muscles are as follows : (1) the lingualis superficialis, (2) the lingualis inferior, (3) the lingualis transversus, and (4) the lingualis verticalis.

The **lingualis superficialis** is an expanded sheet placed on the dorsum, immediately beneath the mucous membrane. Its fibres are disposed longitudinally, and the muscle extends from the tip backwards to the body of the hyoid bone. Posteriorly it is overlapped by fibres of the hyo-glossus. Its fibres do not extend over the whole length of the tongue, but take attachment, at short intervals, to the mucous membrane.

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The **lingualis inferior** is disposed as a round bundle on the inferior surface of the tongue. Posteriorly it lies between the insertions of the genio-hyo-glossus internally and the hyo-glossus externally, and anteriorly between the former muscle internally and the stylo-glossus externally. The muscle extends from the tip of the tongue to the body of the hyoid bone, with which it is connected.

The **lingualis transversus** constitutes a layer of considerable thickness, which is placed between the lingualis superficialis and

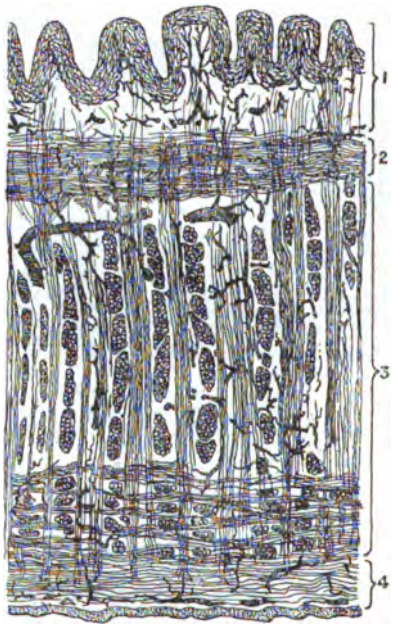

FIG. 490.—LONGITUDINAL SECTION OF THE TONGUE OF A CAT (INJECTED).

1. Mucosa
2. Lingualis Superficialis
3. Lingualis Transversus et Verticalis
4. Lingualis Inferior

lingualis inferior. It arises from the median septum, and extends outwards, the upper fibres curving upwards, to be inserted into the mucous membrane of the side of the tongue and adjacent portion of the dorsum. This muscular stratum is interspersed with fat, and is much broken up by fibres of the lingualis verticalis and genio-hyo-glossus.

The **lingualis verticalis** extends from the mucosa of the dorsum to that of the inferior surface. Its fibres describe curves, having the convexities directed inwards, and they decussate freely with the fibres of the lingualis transversus.

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Arteries.—These are as follows: (1) the **ranine artery,** which is a branch of the lingual, and is situated on the inferior surface, immediately external to the line of insertion of the genio-hyo-glossus muscle. It anastomoses with its fellow beneath the tip. (2) The **dorsalis linguæ** artery, which is also a branch of the lingual. (3) The **tonsillar branch** of the *cervical portion of the facial* artery. (4) The **palatine branch** of the *ascending pharyngeal* artery.

The **veins** pass to the internal jugular vein.

Lymphatics.—The lymphatics of the anterior part of the tongue pass through the mylo-hyoid muscle to the submaxillary lymphatic glands. Those from the posterior part of the organ pass to the lingual lymphatic glands which are situated on the hyo-glossus muscle, and thence to the upper group of deep cervical glands.

Nerves.—The *sensory nerves* are: (1) the **lingual branch** of the *inferior maxillary division of the fifth cranial* nerve, which is distributed to the mucous membrane over the *anterior two-thirds* of the tongue, including the *conical* and *fungiform papillæ*, upon which it confers common sensibility; (2) the **chorda tympani** nerve, which accompanies the lingual nerve to the anterior two-thirds of the tongue, of which it is usually regarded as the nerve of *special sense;* (3) the **lingual branch** of the *glosso-pharyngeal* nerve, which is distributed to the mucous membrane of the *posterior third* and to the *circumvallate papillæ*, of which it is the nerve of special sense; (4) the **internal branch** of the *superior laryngeal nerve*, which furnishes a few twigs to the mucous membrane of the *root of the tongue*, in the region of the epiglottis; and (5) the **hypoglossal nerve,** which supplies the lingual muscles.

Sympathetic filaments are also conducted to the tongue by the various arteries.

Taste-buds.—These are principally met with on the sides of the circumvallate papillæ, and on the surface of each vallum. They are also present in some fungiform papillæ, over the tongue generally, more especially towards the root, on the buccal surface of the soft palate, and on the epiglottis. They are situated in the thick stratified epithelium. A taste-bud is somewhat ovoid or flask-shaped. The superficial end is narrow, and presents a *gustatory pore*, by which it communicates with the buccal cavity, and through which the distal process of a gustatory cell projects. The base rests upon the mucosa, and gives passage to a nerve-fibre. The wall of the taste-bud is composed of flattened, nucleated epithelial cells, called the **tegmental** or **sustentacular cells,** which are pointed at either end, and cohere by their edges, very much like the staves of a barrel. The interior of the taste-bud contains a bundle of gustatory cells. Each **gustatory cell** contains a nucleus, and is fusiform or spindle-shaped. It is prolonged into two poles. The *distal* or *outer pole* projects through the gustatory pore, at the apex of the bud, in a filiform manner. The *proximal* or *inner pole* is usually branched, and becomes continuous with a nerve-fibre at the base of the bud.

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Development.—The *buccal* or *papillary portion* of the tongue (anterior two-thirds) is developed from the **tuberculum impar,** and the *pharyngeal* or *lymphoid portion* (posterior third) is developed from the **ventral ends of the second and third visceral arches on each side.** The **tuberculum impar** makes its appearance as a round eminence in the median line, opposite and between the first visceral clefts. Behind it, and separated from it by a groove, is the **furcula**, which is a forked eminence, mesially placed opposite the second and third visceral arches, and resembling a horseshoe. It gives origin to the

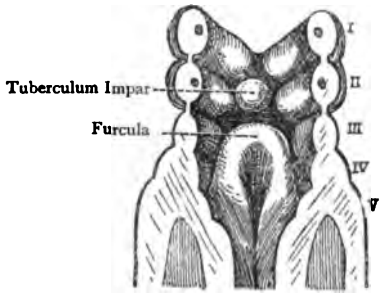

FIG. 491.—THE VISCERAL ARCHES OF THE EMBRYO (POSTERIOR VIEW) (HIS).

I. Mandibular Arch
II. Hyoid Arch
III. Thyro-hyoid Arch
IV. Fourth Arch
V. Fifth Arch

epiglottis and aryteno-epiglottidean folds. The ventral ends of the second and third visceral arches of either side coalesce, and the united ends of these arches join each other in the interval between the tuberculum impar and the furcula. It is from this transverse elevation that the *root* of the tongue is formed. It is developed from it as two elevations, which take an upward and forward direction, diverging at the same time in a V-shaped manner, so as to embrace the part developed from the tuberculum impar. The tuberculum impar, as stated, gives rise to the buccal portion of the tongue. After the pharyngeal and buccal portions of the tongue have coalesced, a V-shaped groove persists for some time, indicating the line of union of the two parts of the organ ; and in adult life this is represented by the *sulcus terminalis.*

The Soft Palate.

The soft palate, or *velum pendulum palati*, is a movable musculo-aponeurotic curtain situated at the back part of the hard palate, where it projects downwards and backwards into the pharynx. Anteriorly it is attached to the posterior border of the hard palate, laterally it is connected with the side of the tongue and the wall of the pharynx, and postero-inferiorly it presents a free border. Its surfaces, which occupy an oblique plane, are antero-inferior or buccal, which is concave, and postero-superior or pharyngeal, which is convex and looks towards the naso-pharynx. The postero-inferior border at its centre presents a conical process, called the **uvula.** On either side of the base of the uvula there are two prominent folds of mucous membrane, which extend outwards and downwards in a diverging manner. These folds constitute the

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anterior and **posterior pillars of the fauces.** Each posterior pillar belongs to the postero-inferior border of the soft palate, and it sweeps outwards, downwards, and backwards on the lateral wall of the pharynx. It is due to the palato-pharyngeus muscle. Each anterior pillar belongs to the buccal surface of the soft palate, and it sweeps outwards, downwards, and forwards to the back part of the side of the tongue. It is produced by the palato-glossus muscle. Between the diverging anterior and posterior pillars, on either side, there is a triangular interval, which is occupied by the tonsil. The passage which leads from the buccal cavity into the pharynx is called the **fauces** or **isthmus faucium**. It is somewhat constricted, and is bounded above by the soft palate, below by the

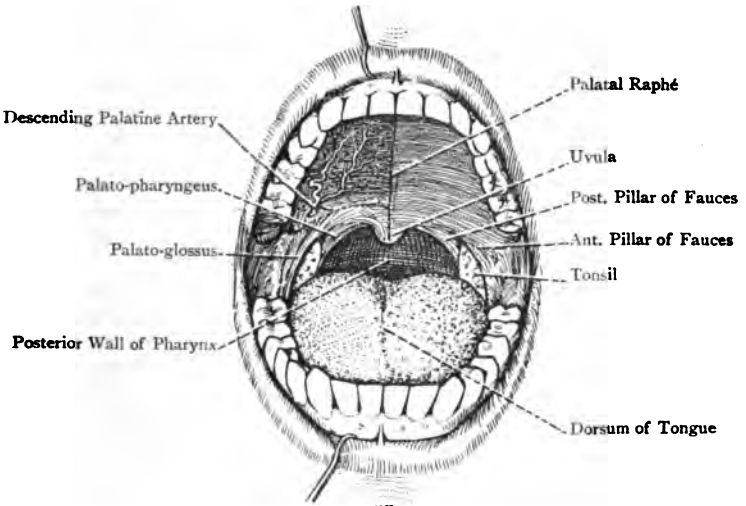

FIG. 492.—THE BUCCAL CAVITY AND ISTHMUS FAUCIUM.
(The Maxillæ are widely separated).

back part of the dorsum of the tongue, and on either side by the anterior pillar of the fauces.

The buccal surface of the soft palate presents a faint mesial raphé.

Structure.—The soft palate is composed of a double fold of mucous membrane, which contains between its two layers an aponeurosis, muscles, and many racemose glands, with bloodvessels and nerves. The **mucous membrane** on the buccal surface presents, as stated, a median raphé, which is continuous with that on the mucous membrane of the hard palate, and along which the originally separate halves of the soft palate unite. On the buccal surface and along the postero-inferior border it is covered by stratified squamous

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epithelium, but on the pharyngeal surface by ciliated columnar epithelium. The **glands**, which are racemose or acinous, are especially abundant on the buccal surface beneath the mucous membrane, where they are closely packed together. The **aponeurosis** is attached anteriorly to the posterior border of the hard palate, and laterally it becomes continuous with the aponeurosis of the pharynx. It affords attachment to portions of the palatal muscles.

Muscles.—These are arranged in pairs, and are as follows: palato-glossus, palato-pharyngeus, azygos uvulæ, levator palati, and tensor palati.

Palato-glossus (Constrictor Isthmi Faucium)—*Origin.*—The under surface of the palatal aponeurosis, its fibres being continuous across the middle line with those of the opposite muscle.

Insertion.—The back part of the side of the tongue, where its fibres blend with the transverse muscular fibres of the tongue.

Nerve-supply.—The pharyngeal plexus.

The direction of the muscle is outwards, downwards, and forwards.

Action.—(1) To depress the side of the soft palate, and (2) to draw the tongue upwards and backwards. The two muscles also approximate the anterior pillars of the fauces. By means of these combined actions, aided by the tongue, the isthmus faucium is closed, and the anterior part of the buccal cavity is shut off from the pharynx at the commencement of the second stage of deglutition.

The muscle forms the lowest layer in the soft palate, and it gives rise to the mucous fold, called the anterior pillar of the fauces.

Palato-pharyngeus—*Origin.*—By two layers, upper and lower. The **upper small layer** arises from the aponeurosis of the soft palate above the azygos uvulæ, its fibres decussating with those of the opposite side; and the **lower large layer** arises from the posterior margin of the hard palate, as well as from the palatal aponeurosis, decussating with its fellow of the opposite side.

Insertion.—(1) The superior and posterior borders of the ala of the thyroid cartilage, and (2) the lateral and posterior wall of the pharynx, its fibres blending with those of the stylo-pharyngeus.

The muscle receives an accessory slip from the lower part of the cartilage of the Eustachian tube, which is known as the *salpingo-pharyngeus muscle.*

Nerve-supply.—The pharyngeal plexus.

The muscle is directed downwards and backwards.

Action.—(1) To approximate the posterior pillar of the fauces to its fellow at the commencement of the second act of deglutition, and (2) to elevate the pharynx.

The muscle gives rise to the mucous fold, called the posterior pillar of the fauces.

Azygos Uvulæ—*Origin.*—The side of the posterior nasal spine and the adjacent aponeurosis.

Insertion.—The submucous tissue of the uvula, having previously united with its fellow of the opposite side.

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Nerve-supply.—The pharyngeal plexus. The direction of the muscle is backwards and downwards.

Action.—To elevate and shorten the uvula.

The muscle lies above the levator palati, and beneath the upper layer of the palato-pharyngeus.

Levator Palati—*Origin.*—(1) The rough surface on the inferior aspect of the petrous part of the temporal bone between the apex and the carotid foramen, and (2) the lower margin of the cartilage of the Eustachian tube.

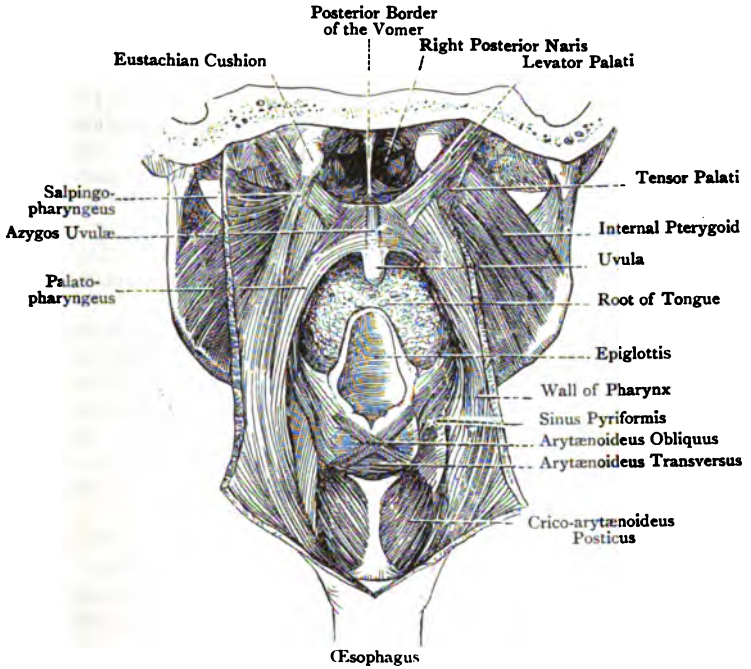

FIG. 493.—THE PHARYNX OPENED FROM BEHIND.

Insertion.—The aponeurosis of the soft palate, its posterior fibres becoming continuous across the middle line with the corresponding fibres of the opposite muscle.

Nerve-supply.—The pharyngeal plexus. Another view, however, is that the muscle is supplied by the posterior descending palatine nerve from Meckel's ganglion, which conveys fibres of the facial nerve through the great superficial petrosal and Vidian nerves.

The muscle is directed downwards, forwards, and inwards.

Action.—(1) To raise the soft palate, and (2) to press upwards the membranous floor of the Eustachian tube, and so lead to closure of the Eustachian orifice during deglutition (Cleland).

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The muscle, which is round and fleshy, passes over the upper border of the superior constrictor and through the pharyngeal aponeurosis. At its origin it is closely related to the membranous portion of the Eustachian tube.

Tensor Palati—*Origin.*—(1) The scaphoid fossa at the root of the internal pterygoid plate of the sphenoid; (2) the spine of the sphenoid; and (3) the outer side of the Eustachian tube.

Insertion.—(1) The transverse ridge on the under surface of the horizontal plate of the palate bone, near the posterior border; and (2) the aponeurosis of the soft palate.

Nerve-supply.—A branch from the otic ganglion. Two views are maintained as to the source from which the nerve-fibres are derived. One view is that they come from the inferior maxillary division of the fifth cranial nerve, through the branch to the internal pterygoid muscle, which branch furnishes motor fibres to the ganglion. The other view is that the nerve-fibres are derived from the small superficial petrosal nerve which joins the ganglion, and which represents the tympanic branch (Jacobson's nerve) of the glosso-pharyngeal, reinforced by a small branch from the geniculate ganglion of the facial. According to this latter view the glosso-pharyngeal nerve would be concerned in the innervation of this muscle (Turner).

The muscle at first descends vertically as a flat fleshy band between the internal pterygoid plate and the internal pterygoid muscle, being in close contact with the mesial surface of the latter. As it approaches the hamular process it ends in a tendon, which turns round that process, a synovial bursa intervening, and then passes horizontally inwards, expanding as it does so. From the fact that the muscle is bent around the hamular process it has been called the **circumflexus palati.**

Action.—(1) To make tense the soft palate, and (2) to draw downwards and backwards the margins of the cartilage of the Eustachian tube, and so open the tube during deglutition. (See action of levator palati.) The muscle comes into play during the second stage of deglutition.

Sensory Nerves.—These are (1) the posterior and external palatine nerves from Meckel's ganglion, and (2) the tonsillitic branches of the glosso-pharyngeal.

Arteries.—The soft palate is supplied by the following arteries: (1) the inferior or ascending palatine of the cervical portion of the facial; (2) the palatine branch of the ascending pharyngeal; and (3) the posterior and external branches of the descending palatine artery from the internal maxillary, which descend in the posterior and external accessory palatine canals.

Relation of Structures in the Soft Palate.—Supposing the soft palate to be transfixed from its buccal to its pharyngeal surface, the following structures would be pierced in the order stated: (1) the mucous membrane covering the buccal surface, (2) the layer of closely-set racemose glands, (3) the palato-glossus, (4) the lower

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layer of the palato-pharyngeus, (5) the palatal aponeurosis and tensor palati, (6) the levator palati, (7) the azygos uvulæ, (8) the upper layer of the palato-pharyngeus, and (9) the mucous membrane covering the pharyngeal surface.

The Tonsils.

The tonsils (*amygdalæ*) are two in number, right and left. Each is situated in the triangular depression between the anterior and posterior pillars of the fauces on either side, and, above it, is a small recess, known as the **supratonsillar fossa,** which is the remains of the inner portion of the second visceral cleft. The tonsil stands out as an oval enlargement, covered by mucous membrane, and it lies opposite the angle of the inferior maxilla, being under cover of it and

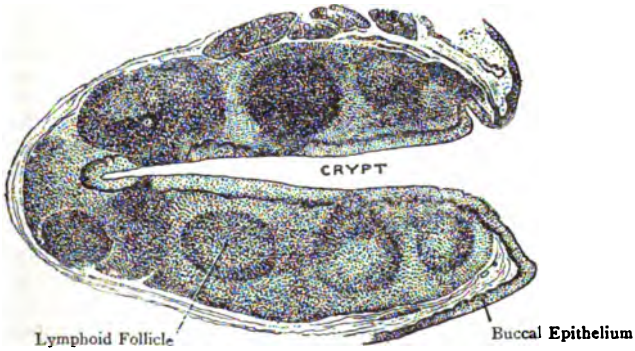

FIG. 494.—SECTION THROUGH A CRYPT OF THE TONSIL.

the adjacent portion of the ramus. The organ varies much in size, but on an average it measures about 1 inch in length, about ¾ inch from before backwards, and about ½ inch from within outwards. The internal surface is pitted with a number of orifices, which lead into crypts in the interior. The outer surface, which has a fibrous covering, is related to the superior constrictor of the pharynx, some loose tissue intervening, and external to the superior constrictor is the internal pterygoid muscle. Two of the tonsillar arteries, namely, the tonsillar and inferior or ascending palatine, lie between the superior constrictor and internal pterygoid. The cervical portion of the facial artery in its course lies a little below the outer aspect of the tonsil. The internal carotid artery is situated about 1 inch from it on its outer and posterior aspect.

Arteries.—These are as follows: (1) the tonsillar and inferior or ascending palatine branches of the cervical portion of the facial; (2) the ascending pharyngeal branch from the external carotid; (3) the dorsalis linguæ from the lingual; and (4) the posterior and

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external palatine offsets of the descending palatine artery from the third part of the internal maxillary.

The **veins** form a plexus on the outer surface of the tonsil, from which the blood passes into the pharyngeal plexus.

Lymphatics.—These pass to the upper group of deep cervical glands.

Nerves.—The nerves are derived from (1) the glosso-pharyngeal, (2) the posterior and external palatine branches of Meckel's ganglion, and (3) the sympathetic.

Structure.—The tonsils are composed of lymphoid follicles. The follicles are ranged upon the sides of the crypts which penetrate into the organ, these crypts being lined with mucous membrane, covered by stratified squamous epithelium. Lymph corpuscles migrate from the follicles into the crypts, and become salivary corpuscles.

Development.—The tonsil and supratonsillar fossa are developed from the dorsal extremity of the *second visceral cleft*.

The Nasal Fossæ.

The nasal fossæ extend from the anterior nares to the posterior nares. Anteriorly they open upon the face, and posteriorly they open into the naso-pharynx. Each fossa is narrow above, but expanded below. It presents two walls, outer and inner, a roof, and a floor. The **outer wall** is rendered very irregular by three convoluted bony eminences, disposed antero-posteriorly, which bulge into the fossa. These are the superior and inferior turbinate processes of the ethmoid, and the inferior turbinate bone. They are also known as the superior, middle, and inferior spongy bones, or **conchæ.** They overhang deep channels, which are known as the **meatûs**—superior, middle, and inferior respectively.

The **superior meatus** is confined to the back part of the outer wall, and lies between the superior and middle conchæ. It is short and oblique, and opening into it there are (1) the spheno-palatine foramen, which leads from the spheno-maxillary fossa, and (2) the posterior ethmoidal cells, by one or more openings. Above and behind the superior concha is a depression, called the *spheno-ethmoidal recess*, into which the sphenoidal air-sinus opens.

The **middle meatus** is situated between the middle and inferior conchæ, is directed from behind forwards, and is overhung by the middle concha. Anteriorly it describes a bend, and passes upwards under cover of the front part of the middle concha, to be continued into the *infundibulum*, which leads from the frontal air-sinus of the corresponding side. The openings into the middle meatus are as follows: (1) the infundibulum, leading from the frontal air-sinus, with the opening of the anterior ethmoidal cells; (2) the opening of the maxillary air-sinus or antrum of Highmore; and (3) one or two openings of the middle ethmoidal cells. These various openings

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are concealed by the middle concha. When this is removed the lateral wall of the middle meatus is seen to present a deep curved groove, called the **hiatus semilunaris,** which is directed downwards and backwards from the lower end of the infundibulum. Behind and above this hiatus there is a round prominence, called the **bulla ethmoidalis.** The opening of the anterior ethmoidal cells is situated in the vertical portion of the hiatus semilunaris, and the opening of the antrum of Highmore, which is of small size, is placed

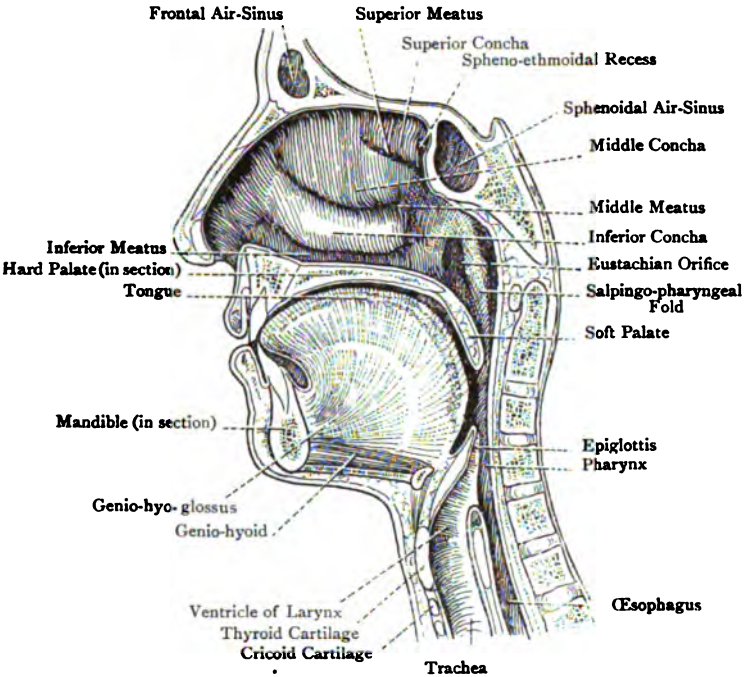

FIG. 495.—SAGITTAL SECTION THROUGH THE NASAL FOSSA, MOUTH, PHARYNX, ŒSOPHAGUS, AND LARYNX.

(The Outer Wall of the Right Nasal Fossa is shown).

in its horizontal portion, whilst the middle ethmoidal cells open above the bulla ethmoidalis. In front of the middle meatus is the region known as the **atrium,** which communicates anteriorly with the **vestibule,** the latter being situated just within the ala of the nostril.

The **inferior meatus** is situated below the inferior concha. Opening into its anterior part, under cover of the inferior concha, is the lower orifice of the nasal duct, which is provided with an imperfect mucous fold, called the **valve of Hasner.** The orifice is about 1¼ inches from the anterior nasal aperture.

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The **inner wall** forms the *septum nasi*.

The **roof,** which is narrow, is horizontal in its central part, the anterior portion being sloped downwards and forwards, and the posterior portion downwards and backwards.

The **floor** is smooth, and at its anterior and inner part is the incisor foramen, into which a funnel-shaped portion of the mucous membrane extends. This region represents the wide communication which existed in early life between the nasal and buccal cavities.

Each nasal fossa is divided into three regions—vestibular, olfactory, and respiratory. The **vestibular region,** or **vestibule,** forms the anterior and lower part contiguous to the nostril. It is covered by skin, which is provided with hairs or *vibrissæ*. The **olfactory**

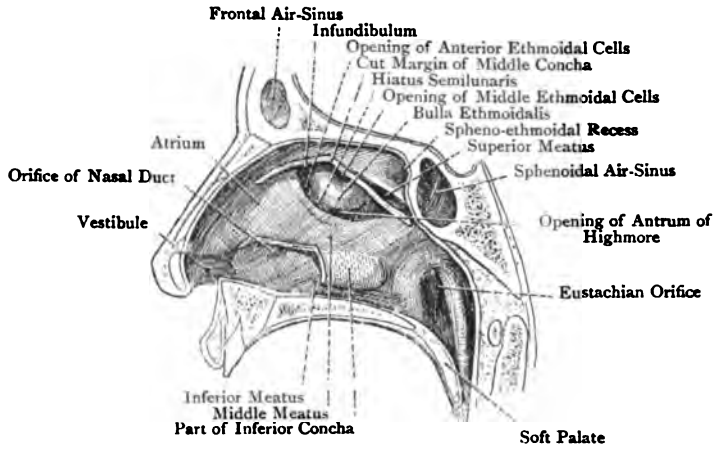

FIG. 496.—THE OUTER WALL OF THE RIGHT NASAL FOSSA.

(The Superior and Middle Conchæ and part of the Inferior Concha have been removed).

region is situated superiorly, and corresponds to the superior concha and the upper third of the septum nasi. The **respiratory region** comprises the middle and inferior conchæ, the middle and inferior meatûs, and the corresponding part of the septum.

Mucous Membrane.—With the exception of the vestibule, which is lined with skin, the nasal fossa is provided with a highly vascular and sensitive mucous membrane, called the **pituitary** or **Schneiderian membrane.** It is continuous through the posterior nares with the mucous membrane of the naso-pharynx; with that of the nasal duct, lachrymal sac, and lachrymal canaliculi, and thence with the conjunctiva; and with that of the various air-sinuses which communicate with the nasal fossa. It is thick and spongy over the conchæ, especially along the lower borders of the middle

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and inferior conchæ, and also on the septum nasi, but over the floor, atrium, and meatûs it is comparatively thin. It is freely provided with acinous glands, and contains a certain amount of lymphoid tissue.

The epithelium varies in different regions. In the vestibular region, where the lining membrane is skin, the epithelium is of the stratified squamous variety; in the respiratory region, as well as in

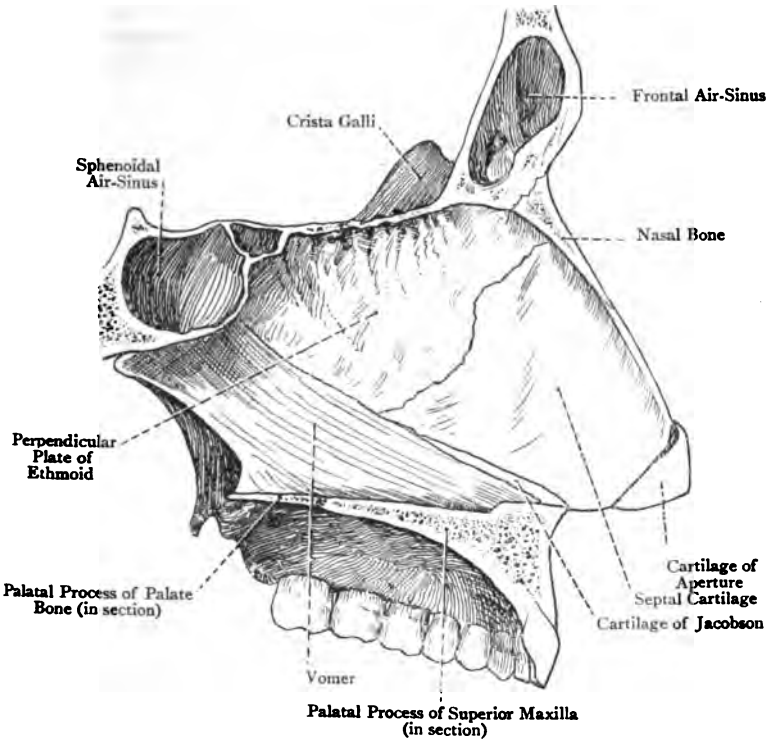

FIG. 497.—THE OSSEOUS AND CARTILAGINOUS NASAL SEPTUM (RIGHT LATERAL VIEW).

the air-sinuses, it is stratified, columnar, ciliated epithelium; and in the olfactory region it is non-ciliated columnar epithelium.

Olfactory Mucous Membrane.—In the olfactory region the mucous membrane is thick and pulpy, and has a yellowish-brown colour, due to pigment in the epithelial cells. It contains a copious plexus of olfactory nerve-fibres, and many serous glands, which are known as the **glands of Bowman.** The **epithelium** is thick, and, as just stated, is of the non-ciliated columnar variety, its free surface being covered by a delicate limiting membrane. The cells

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of which it is composed are of three kinds. (1) Long columnar nucleated cells, called the **sustentacular cells,** the deep ends of which are prolonged each into a branched process. (2) Between these sustentacular cells there are the olfactory cells, which are elongated and spindle-shaped. Each contains an almost spherical nucleus, and has a superficial and a deep process or pole. The *superficial pole* extends through the limiting membrane to the free surface, and projects slightly in the form of a tuft of delicate hair-like filaments called the **olfactory hairs.** The *deep pole*, which is a delicate varicose filament, extends towards the mucosa, where it becomes continuous with one of the nerve-fibrils of the olfactory

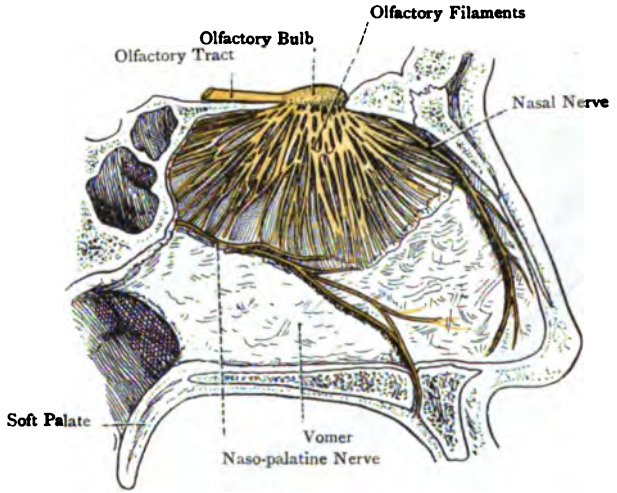

FIG. 498.—THE NERVES OF THE NASAL SEPTUM (HIRSCHFELD AND LEVEILLÉ).

plexus. (3) In the deep part of the epithelium there are in some places **conical cells,** the broad ends of which rest upon the basement membrane.

Olfactory Nerves.—These are from fifteen to twenty in number on each side. After leaving the inferior surface of the olfactory bulb, they pass through the foramina in the corresponding half of the cribriform plate of the ethmoid bone, and so reach the upper part of the nasal fossa, invested by prolongations of the membranes of the brain. Within the nasal fossa they are arranged in two groups, inner and outer. The nerves of the *inner group* are distributed to the mucous membrane of the septum nasi over about its upper third. The nerves of the *outer group* are distributed to the mucous membrane in the region of the superior concha and olfactory sulcus. The nerves form a copious plexus in the mucous membrane, and the filaments which issue from this plexus become continuous, as

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stated, with the deep poles of the olfactory cells. The olfactory nerves are destitute of a medullary sheath.

Nerves of Ordinary Sensation.—These are derived from the ophthalmic and superior maxillary divisions of the fifth cranial nerve, and are as follows :

1. Superior nasal nerves.
2. Nasal branches of the Vidian nerve.
3. Inferior nasal nerves.
4. Internal branches of the nasal nerve.
5. Nasal branch of the anterior superior dental nerve.
6. Naso-palatine nerve.

The **superior nasal nerves** are derived from Meckel's ganglion. They enter the superior meatus through the spheno-palatine foramen, and are distributed to the mucous membrane (1) over the superior and middle conchæ, (2) over the upper and back part of the septum nasi, and (3) within the posterior ethmoidal cells.

The **nasal branches of the Vidian nerve** pierce the floor of the pterygoid or Vidian canal, and are distributed to the mucous membrane over the back part of the roof of the nasal fossa and the adjacent part of the septum.

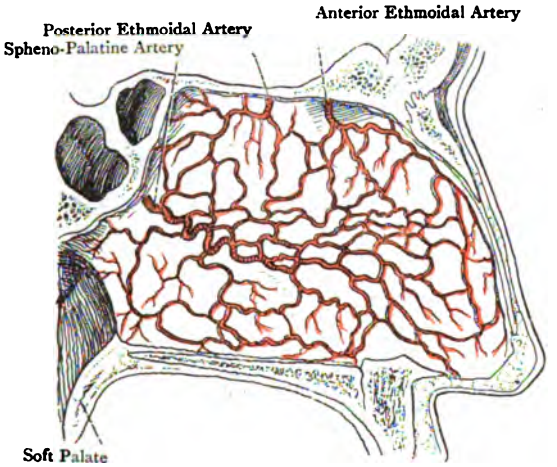

FIG. 499.—THE ARTERIES OF THE NASAL SEPTUM (HIRSCHFELD AND LEVEILLÉ).

The **inferior nasal nerves** arise from the great or anterior descending palatine branch of Meckel's ganglion, as that nerve traverses the posterior palatine canal. They enter the nasal fossa through foramina in the vertical plate of the palate bone, and are distributed to the mucous membrane over the greater part of the inferior concha, and the corresponding parts of the middle and inferior meatûs.

The **internal branches of the nasal nerve** are two in number, septal and external. The *septal branch* is distributed to the mucous membrane over the anterior and upper part of the septum, and the *external branch* to that over the anterior portions of the middle and inferior conchæ, and over the outer wall in front of these.

The **nasal branch of the anterior superior dental nerve** is distributed to the mucous membrane over the anterior part of the inferior meatus and the adjacent part of the floor of the nasal fossa.

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The **naso-palatine nerve,** or **nerve of Cotunnius,** arises from Meckel's ganglion, and enters the nasal fossa through the spheno-palatine foramen. It then crosses the roof, and so reaches the septum, upon which it descends, with a forward inclination, occupying the groove on the outer surface of the vomer. Thereafter it passes downwards to the anterior part of the hard palate, the *left* nerve traversing the anterior foramen of Scarpa, and the *right* nerve the posterior foramen of Scarpa. As the naso-palatine nerve lies upon the septum nasi it furnishes branches to its mucous membrane.

Arteries of the Nasal Fossa.—These arteries are derived from the following sources :

1. The spheno-palatine.
2. The descending palatine.
3. The Vidian.
4. The anterior ethmoidal.
5. The posterior ethmoidal.
6. The superior coronary.

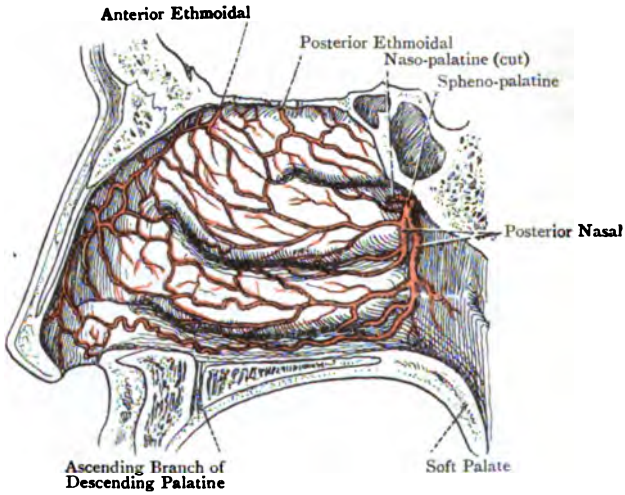

FIG. 500.—THE ARTERIES OF THE EXTERNAL WALL OF THE RIGHT NASAL FOSSA (AFTER HIRSCHFELD AND LEVEILLÉ).

The **spheno-palatine artery** is the principal artery of the nasal fossa. Arising from the third part of the internal maxillary, it enters the fossa through the spheno-palatine foramen. Most of its branches are distributed to the outer wall ; but one, called the *naso-palatine branch*, accompanies the naso-palatine nerve. This branch gives offsets to the septum, and terminates by entering the incisor foramen, where it anastomoses with a branch of the descending palatine artery, which ascends from the palate in the incisor canal (Stensen's canal).

The **descending palatine artery** arises from the third part of the internal maxillary. As it traverses the posterior palatine canal it gives off two or three branches which accompany the inferior nasal nerves through foramina in the vertical plate of the palate bone, to be distributed to the back part of the inferior concha and the adjacent parts of the middle and inferior meatûs.

The **Vidian artery,** arising from the third part of the internal maxillary, traverses the pterygoid or Vidian canal, and furnishes a few twigs which accompany the nasal offsets of the Vidian nerve, and supply the back part of the roof of the nasal fossa and the adjacent part of the septum.

The **anterior** and **posterior ethmoidal arteries** are branches of the ophthalmic. The *anterior ethmoidal* enters the nasal fossa along with the nasal nerve, and furnishes branches to the anterior and upper part of the septum, the front

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part of the outer wall, and the anterior portions of the middle and inferior conchæ. The *posterior ethmoidal* furnishes nasal branches which enter the nasal fossa through some of the foramina in one half of the cribriform plate of the ethmoid bone, and are distributed to the roof and upper part of the septum.

The **superior coronary artery,** a branch of the facial, furnishes the *artery of the septum,* which supplies the anterior part of the septum and the columella nasi.

The **veins** form a copious plexus, especially over the inferior concha and the lower margin and back part of the middle concha. The vessels which carry away the blood from the plexus correspond to the various arteries, and their principal destination is threefold, namely, (1) the pterygoid plexus, (2) the superior ophthalmic vein, and (3) the facial vein. The ethmoidal veins, which open into the superior ophthalmic vein, communicate with the intracranial anterior meningeal veins and with the angular vein of the face by means of twigs which pass through minute apertures in the nasal process of the superior maxilla, and, it may be, through a small foramen in the nasal bone. In those cases where the foramen cæcum is pervious it transmits an emissary vein which passes between the intracranial superior longitudinal sinus and the veins of the roof of the nasal fossa.

Lymphatics.—These are very numerous, and form a plexus which has the following communications: (1) with the lymphatic spaces round the olfactory nerves, and through these with the subdural and subarachnoid spaces; (2) with the lymphatics of the naso-pharynx; and (3) with the lymphatics of the face.

For the development of the nasal fossæ see p. 1161.

Organ of Jacobson.—Jacobson's organ is rudimentary in man, but is well developed in ruminantia. It takes the form of a blind pouch, which is situated in the lower and anterior part of the septum nasi on either side. The minute orifice of the pouch lies above the recess or depression of mucous membrane which projects slightly into the upper end of Stensen's canal. The pouch extends upwards and backwards in the septum nasi for a very short distance, and terminates in a blind extremity. The cartilage of Jacobson lies underneath it. Jacobson's organ does not seem to perform any function in man. In those animals, however, in which it is well developed, *e.g.*, ruminantia, it receives two nerves, one of which is olfactory, the other being derived from Meckel's ganglion. Moreover, its epithelial lining is similar to that of the olfactory region of the nasal fossa, inasmuch as it contains olfactory cells, the deep poles of which are continuous with olfactory filaments. In such animals it acts as a supplementary organ of smell.

Development.—The organ of Jacobson is developed as a diverticulum of the epiblast at the lower and anterior part of the septum nasi, into which latter it grows.

The Pharynx.

The pharynx is situated behind the posterior nares, isthmus faucium, and larynx, and it extends from the basilar region of the base of the skull to the level of the lower border of the cricoid cartilage of the larynx, where it becomes continuous with the œsophagus. It is a musculo-aponeurotic tube, about 5 inches long, and it attains its greatest width between the base of the skull and the hyoid bone. Below the latter level it narrows, and is flattened

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from before backwards, so as to assume the form of a transverse cleft, except during the act of deglutition.

Relations.—*Posteriorly* it rests upon the bodies and discs of the cervical vertebræ as low as the sixth, and the prevertebral muscles covered by the prevertebral fascia. Between it and the last-named fascia is the retropharyngeal space, which is occupied by connective tissue, but this is so loosely arranged that no obstacle is offered to the movement of the tube, and a post-pharyngeal abscess can readily diffuse itself. *Anteriorly* it communicates with (1) the nasal fossæ through the posterior nares, (2) the Eustachian tubes, (3) the

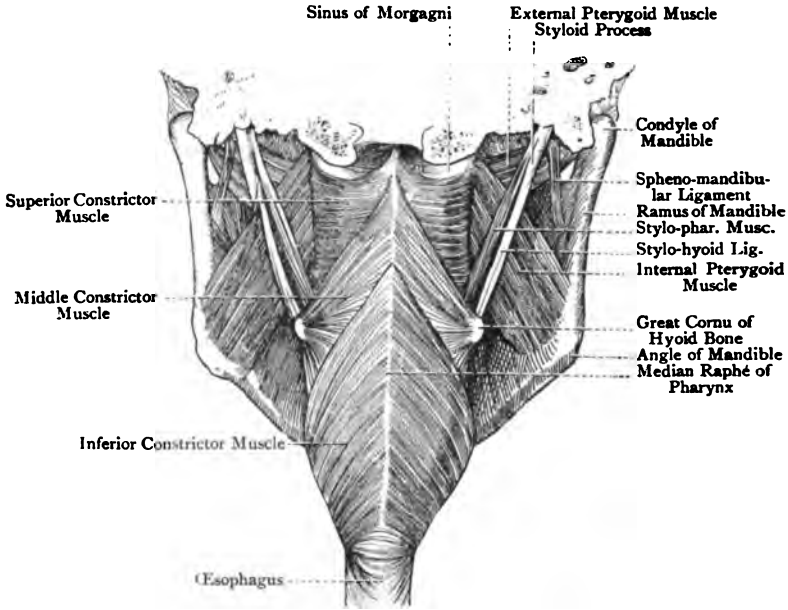

FIG. 501.—THE POSTERIOR WALL OF THE PHARYNX AND ADJACENT STRUCTURES.

buccal cavity through the isthmus faucium, and (4) the larynx. On this aspect its attachments are effected by means of the constrictor muscles in its walls. *Laterally* it is related to the principal bloodvessels and nerves of the neck, and comes into contact with the styloid muscles and the process from which they arise. *Superiorly* it is attached to the basilar region of the base of the skull. *Inferiorly* it is continuous with the œsophagus.

The wall of the pharynx consists of the following four strata, in order from without inwards: (1) the pharyngeal portion of the bucco-pharyngeal fascia, (2) the muscular coat, (3) the pharyngeal aponeurosis, and (4) the mucous coat.

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Pharyngeal Fascia.—This is an offshoot of the prevertebral lamina of the deep cervical fascia along the mesial aspect of the carotid sheath. In front it becomes continuous with the fascia covering the buccinator muscle. In association with this fascial stratum there are many veins upon the posterior and lateral walls of the pharynx, which constitute the pharyngeal venous plexus.

Muscular Coat.—This is composed, on either side, of the three constrictor muscles, inferior, middle, and superior, the stylo-pharyngeus, and the palato-pharyngeus (including the salpingo-pharyngeus).

Inferior Constrictor—*Origin.*—(1) The side of the cricoid cartilage at its posterior part; (2) the inferior cornu and the oblique line of the ala of the thyroid cartilage; and (3) the upper border of the ala behind the superior tubercle.

Insertion.—The median raphé on the posterior wall of the pharynx, where it meets its fellow of the opposite side.

The lower fibres of the muscle are horizontal, but the upper fibres pass upwards and backwards more and more obliquely, and the highest fibres of the two muscles meet in the raphé to form a peak, which is about an inch below the basilar process of the occipital bone. The lower border of the muscle overlaps the upper end of the œsophagus, and, to a limited extent, some of the fibres are continuous with the œsophageal muscular fibres. The recurrent laryngeal nerve and inferior laryngeal artery pass upwards beneath the lower border behind the crico-thyroid joint. The upper border, which is very oblique, overlaps the lower portion of the middle constrictor, and the internal laryngeal nerve and the superior laryngeal artery, on their way to pierce the thyro-hyoid membrane, pass between the two muscles anteriorly.

Middle Constrictor—*Origin.*—(1) The upper surface of the great cornu of the hyoid bone over its entire length, (2) the small cornu, and (3) the hyoid extremity of the stylo-hyoid ligament.

Insertion.—The median raphé on the posterior wall of the pharynx, where it meets its fellow of the opposite side.

The muscle is fan-shaped, and its fibres consequently diverge very much as they pass round to reach the raphé. The inferior fibres descend very obliquely, and are overlapped by the upper fibres of the inferior constrictor, the internal laryngeal nerve and superior laryngeal artery passing to the thyro-hyoid membrane between the two muscles anteriorly. The middle fibres pass more or less transversely. The superior fibres ascend obliquely, and reach the basilar process of the occipital bone. They overlap the lower portion of the superior constrictor, and the stylo-pharyngeus muscle and glosso-pharyngeal nerve pass between the two. The lingual artery rests upon the muscle at the great cornu of the hyoid bone.

Superior Constrictor—*Origin.*—(1) The lower third of the posterior border of the internal pterygoid plate, and the hamular process of the sphenoid bone; (2) the posterior aspect of the pterygo-mandibular ligament, along which it meets the buccinator muscle;

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(3) the posterior extremity of the mylo-hyoid ridge of the lower jaw ; (4) the mucous membrane of the mouth ; and (5) the side of the tongue.

Insertion.—The median raphé on the posterior wall of the pharynx, where it meets its fellow of the opposite side. A few of the highest

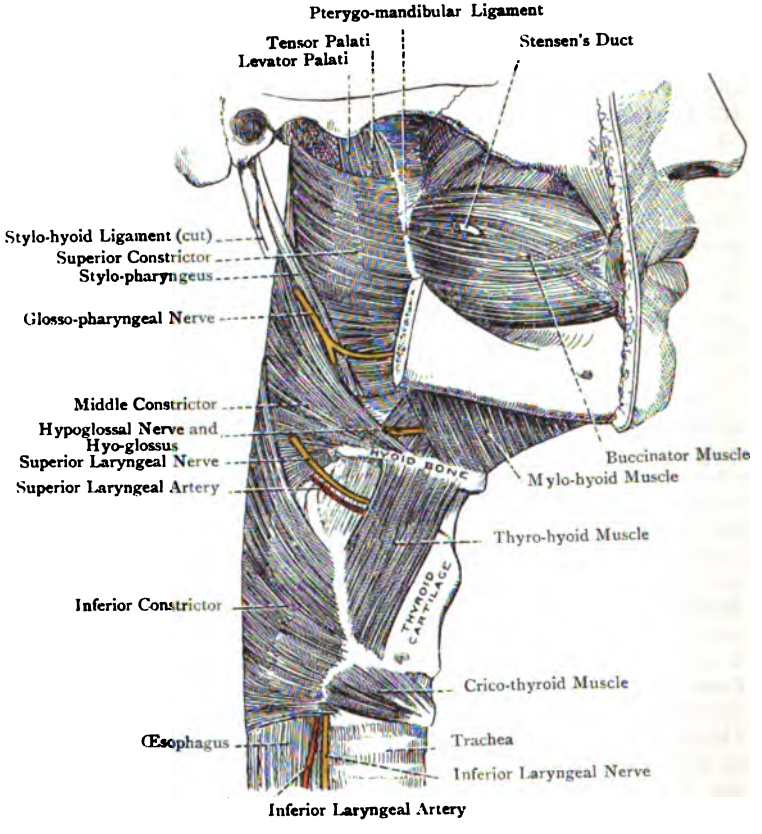

FIG. 502.—DISSECTION SHOWING THE CHEEK, PHARYNX, SUBMAXILLARY REGION, AND LARYNX (RIGHT VIEW).

fibres are inserted into the pharyngeal tubercle on the under surface of the basilar process of the occipital bone.

The muscle is somewhat four-sided. The fibres for the most part pass horizontally, but the lower fibres radiate in a downward direction, whilst the upper fibres curve backwards and upwards. The lower portion of the muscle is overlapped by the upper part of the middle constrictor, the stylo-pharyngeus muscle and glosso-pharyngeal nerve passing between the two. Between the upper

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concave border and the base of the skull there is an interval, occupied by the pharyngeal aponeurosis, which is here stronger than elsewhere, and so compensates for the absence of muscular fibres. This interval is semilunar, and is known as the **sinus of Morgagni.**

Nerve-supply of the Constrictor Muscles.—The nerves are derived from the pharyngeal plexus, which is formed by the pharyngeal branch of the pneumogastric, the pharyngeal branches of the glosso-pharyngeal, and sympathetic filaments. The motor fibres of the plexus are derived from the pharyngeal branch of the pneumogastric, but their ultimate source is the **bulbar portion of the spinal accessory nerve.** The inferior constrictor muscle also receives twigs from (1) the external laryngeal branch of the superior laryngeal nerve, and (2) the inferior or recurrent laryngeal nerve as it passes beneath the lower border of the muscle.

Action.—The constrictor muscles are concerned in the act of deglutition. The superior constrictor and upper portion of the middle constrictor act upon the naso-pharynx, that is, the compartment of the pharynx which lies above the soft palate, and is in communication with the nasal fossæ through the posterior nares. They narrow the naso-pharynx in the lateral direction, and this movement, in conjunction with the action of the posterior pillars of the fauces, shuts off the naso-pharynx, thus preventing regurgitation into and through the nasal fossæ. The lower portion of the middle constrictor and the inferior constrictor diminish the calibre of the buccal compartment of the pharynx. Coming into action during the second stage of deglutition, they grasp the bolus of food and press it downwards into the œsophagus. The constrictor muscles contract rapidly, and in order from above downwards.

For a description of the stylo-pharyngeus and palato-pharyngeus muscles (including the salpingo-pharyngeus), see pp. 1143 and 1170.

Pharyngeal Aponeurosis.—This is situated between the muscular coat and the mucosa. Inferiorly it is weak and indistinct, but superiorly it acquires greater firmness and density, especially where it is attached to the basi-occipital, the apex of the petrous part of the temporal bone, the adjacent portion of the Eustachian tube, and the internal pterygoid plate of the sphenoid bone. It receives an accession of strength in the median line from a strong bundle of fibres which descends from the pharyngeal tubercle on the under surface of the basilar process of the occipital bone, and which form the raphé of the pharynx.

Interior of the Pharynx.—The mucous membrane, which forms the fourth stratum in the pharyngeal wall, is of a papillary character, and has the following important continuations: (1) with the mucous membrane of the Eustachian tube, and thence with that of the tympanum or middle ear; (2) with that of the nasal fossæ through the posterior nares; (3) with that of the buccal cavity through the isthmus faucium; (4) with that of the larynx through the superior laryngeal aperture; and (5) with that of the œsophagus. At its upper and back part it is richly provided with lymphoid tissue,

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to be presently referred to, and in the submucous tissue there are many acinous glands of a mucous character.

The soft palate projects into the cavity of the pharynx in a downward and backward direction, and divides it into two regions, upper and lower. The upper region is known as the naso-pharynx, and is in communication with the nasal fossæ and Eustachian tubes. It also communicates with the lower region by means of the **pharyngeal isthmus.** The lower region is subdivided into two

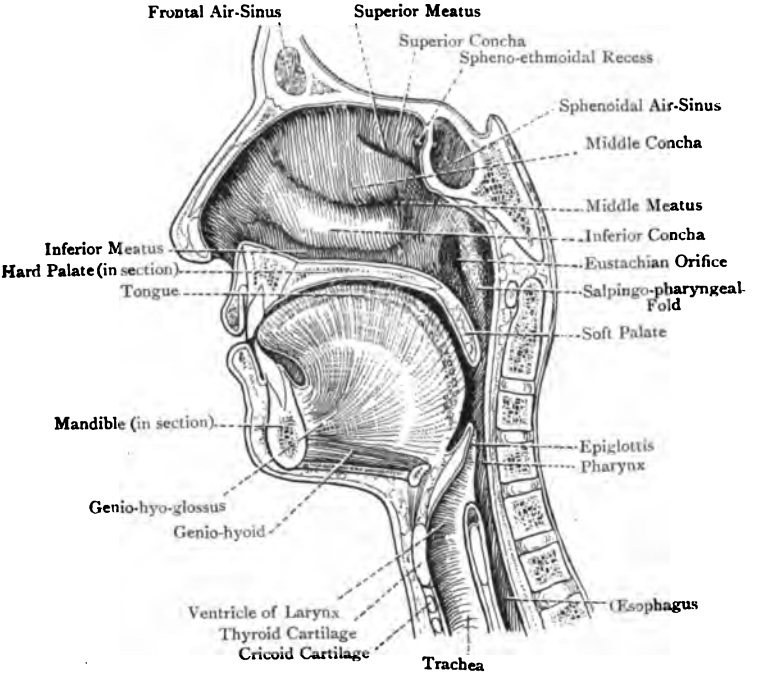

FIG. 503.—SAGITTAL SECTION THROUGH THE NASAL FOSSA, MOUTH, PHARYNX, ŒSOPHAGUS, AND LARYNX.

(The Outer Wall of the Right Nasal Fossa is shown).

parts, buccal and laryngeal. The buccal part is limited above by the soft palate, and below by the superior aperture of the larynx, and it communicates with the buccal cavity through the isthmus faucium. The laryngeal part is situated behind the larynx, with which it communicates, as well as with the œsophagus inferiorly.

Naso-pharynx.—This is entirely respiratory in function, and is consequently always pervious. It is bounded in front by the posterior nares and the posterior border of the vomer; behind, by the vertebral column; above, by the basilar process of the occipital

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and part of the body of the sphenoid ; and below by the soft palate, which can be elevated and depressed. Four openings communicate with the naso-pharynx. The anterior wall presents the oval openings of the posterior nares leading from the nasal fossæ, and separated from each other by the posterior border of the vomer. Each opening in the recent state measures about 1 inch from above downwards, and about ½ inch from side to side. Through it, on the outer wall of the corresponding nasal fossa, are seen the posterior parts of the inferior turbinate bone and the inferior turbinate

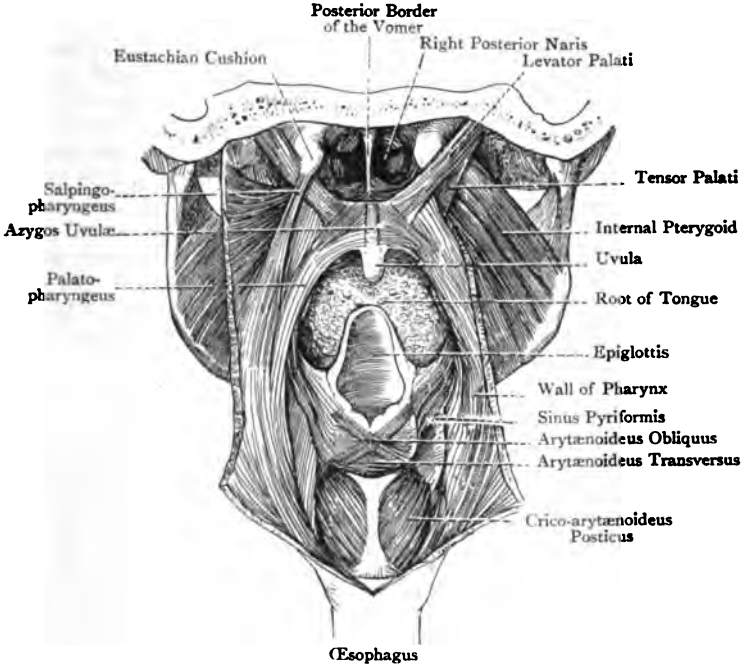

FIG. 504.—THE PHARYNX OPENED FROM BEHIND.

process of the ethmoid bone, covered by mucous membrane ; and above and below the inferior turbinate bone are seen the posterior parts of the middle and inferior meatûs. The orifice of the Eustachian tube is situated on each lateral wall, behind and external to the corresponding posterior naris, and on the same level as the posterior end of the inferior turbinate bone. It is somewhat oval, and presents, above and behind, a prominent round border, formed of cartilage, called the *cushion*. Behind the cushion there is a deep pouch on the lateral wall of the naso-pharynx, called the **lateral pharyngeal recess,** or **fossa of Rosenmüller,** which represents the upper part of the pharyngeal portion of the second visceral cleft. The mucous membrane extending between the lateral pharyngeal

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recesses, at the upper and back part, presents a number of folds containing a large amount of lymphoid tissue, which constitute the **pharyngeal tonsil.** When enlarged this mass is liable to obstruct the Eustachian orifices, and even the posterior nares. At the lower part of the pharyngeal tonsil there may be seen a small median recess, called the **pharyngeal bursa,** which leads upwards and backwards towards the pharyngeal tubercle on the basilar process of the occipital bone.

The mucous membrane is covered by ciliated columnar epithelium.

Buccal Part of the Pharynx.—This part is situated between the soft palate and the superior aperture of the larynx. Anteriorly it communicates with the buccal cavity through the isthmus faucium, below which is the root of the tongue. Each lateral wall presents the posterior pillar of the fauces, the interval between the two pillars corresponding to the pharyngeal isthmus. In front of each posterior pillar is a triangular depression which lodges the tonsil.

Laryngeal Part of the Pharynx.—This part is situated behind the larynx. Anterior to it there are the epiglottis, the superior aperture of the larynx, on either side of which is a recess called the **sinus pyriformis,** and the posterior parts of the arytenoid and cricoid cartilages, with the muscles related to them. It communicates with the larynx anteriorly and the œsophagus inferiorly.

The mucous membrane of the buccal and laryngeal portions is covered by stratified squamous epithelium.

Blood-supply.—The **arteries** of the pharynx are derived from several sources, *e.g.*, the ascending pharyngeal branch of the external carotid, the inferior or ascending palatine and tonsillar branches of the cervical part of the facial artery, and the descending palatine and pterygo-palatine branches of the internal maxillary.

The **veins** form a copious *pharyngeal plexus*, which is disposed upon the lateral and posterior walls of the pharynx. It communicates superiorly with the pterygoid venous plexus, and receives tributaries from the soft palate, tonsils, and Eustachian tubes. Inferiorly the blood is conveyed from it into the internal jugular vein directly, or through means of the common facial vein.

Lymphatics.—The lymphatic vessels from the upper part of the pharynx pass to the internal maxillary glands, which are associated with the lateral walls of the tube, and those from the remaining part pass to the upper group of deep cervical glands. Some of the lymphatics from the upper part pass to the **retropharyngeal glands,** two in number, each of which lies upon the upper part of the corresponding rectus capitis anticus major muscle.

Development of the Pharynx, and of the Visceral Clefts and Visceral Arches.

The pharynx is developed from the anterior or cephalic part of the fore-gut.

On the ventral wall of this part there are two elevations, the anterior of which is called the **tuberculum impar,** whilst the posterior is called the **furcula.** The latter has the form of a horseshoe, the open part of which is

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placed posteriorly. The furcula is separated from the tuberculum impar in front, and from the lateral wall of the fore-gut on either side, by a groove called the **sinus arcuatus.** The tuberculum impar gives origin to the anterior two-thirds, or buccal portion, of the tongue; the anterior part or loop of the furcula gives rise to the epiglottis; the posterior extremities of the furcula to the arytenoid cartilages; and the depression within the furcula becomes deepened and developed into the larynx and trachea. Posterior to the furcula the foregut becomes dilated to form the rudimentary stomach, and as this descends the œsophagus is formed.

Visceral Clefts and Visceral Arches.—On each lateral wall of the anterior part of the fore-gut four protrusions of hypoblast take place, to meet which the epiblast dips in, and so four clefts are formed, called the **visceral clefts,** first, second, third, and fourth, from before backwards. The parts of the lateral wall of the fore-gut between the four visceral clefts, the part forming the anterior margin of the first visceral cleft, and the part forming the posterior margin of the fourth visceral cleft, become thickened by the growth of mesoblast between their hypoblastic and epiblastic layers. In this manner

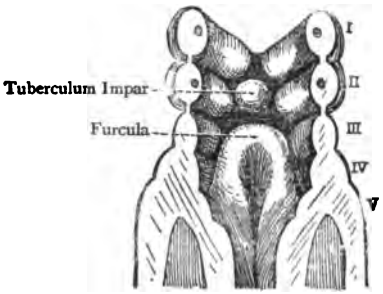

FIG. 505.—THE VISCERAL ARCHES OF THE EMBRYO (POSTERIOR VIEW) (HIS).

I. Mandibular Arch
II. Hyoid Arch
III. Thyro-hyoid Arch
IV. Fourth Arch
V. Fifth Arch

(in the higher vertebrata), five round, curved bars are formed, called the **visceral arches,** each of which has a cartilaginous framework.

The **first** or **mandibular arch** is placed in front of the first visceral cleft, between it and the mouth, and for the most part it gives rise to the mandible, or inferior maxilla. The **maxillary process** is an outgrowth from it superiorly, and gives rise to the principal part of the superior maxilla (exognathion), the malar and palate bones, and, it may be, the internal pterygoid plate of the sphenoid. The skeletal framework of the mandibular arch is known as **Meckel's cartilage.** Its upper part gives rise to the malleus, and, according to some authorities, the incus, and its lower part to the symphysial part of the mandible or inferior maxilla. The intermediate portion disappears, but the fibrous investment of the upper part of this intermediate portion persists as the spheno-mandibular ligament, and that of its lower part gives rise to the chief portion of the mandible or inferior maxilla. The mandibular arch also gives origin to the tragus, and part of the helix, of the auricle.

The **second** or **hyoid arch** is situated between the first and second visceral clefts, and the **third** or **thyro-hyoid arch** between the second and third visceral clefts. These arches on either side join, and the two united portions, blending in the median line, give rise to a transverse eminence in the anterior part of the sinus arcuatus, between the tuberculum impar and the anterior part or loop of the furcula. This transverse eminence gives rise to the posterior third or pharyngeal portion of the tongue. The skeletal cartilaginous framework of the hyoid arch is known as the **hyoid bar.** Its lower part gives rise

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to part of the body, and the whole of the small cornu, of the hyoid bone, and its upper part to the styloid process (both tympano-hyal and stylo-hyal portions) of the temporal bone. The fibrous investment of the intermediate portion persists as the stylo-hyoid ligament. The hyoid arch also gives rise to a part of the helix, antihelix, antitragus, and lobule, of the auricle, and, according to some authorities, to the incus. The lower part of the cartilaginous bar of the third or thyro-hyoid arch gives rise to the great cornu and adjacent portion of the body of the hyoid bone, and the remainder of it disappears. The **fourth visceral arch,** of small size, is situated between the third and fourth visceral clefts, and the **fifth,** which is very small, forms the posterior margin of the fourth visceral cleft. The ventral portion of the cartilaginous bars of these two arches become united with those of the opposite side by a median plate, and they are regarded as giving rise to the thyroid cartilage of the larynx. The remaining portions of the bars disappear.

The hypoblast of the **first visceral cleft** becomes developed into the Eustachian tube and tympanum, and its epiblast forms the meatus auditorus externus. The **second visceral cleft** dorsally gives rise to the tonsil and supra-tonsillar fossa. The **third** and **fourth visceral clefts,** right and left, give origin internally to the diverticula from which the thymus body is developed. The **fourth visceral cleft** of each side gives origin internally to the diverticulum from which the corresponding lateral lobe of the thyroid body is developed.

Eustachian Tube.

The Eustachian tube leads from the tympanum to the naso-pharynx, and is about 1½ inches in length. It is directed forwards, inwards, and slightly downwards, and is composed of two parts, osseous and cartilaginous. The osseous or postero-external part is about ½ inch long, and represents the lower or Eustachian compartment of the canal situated in the angle between the petrous and squamous parts of the temporal bone. The cartilaginous or antero-internal part is about 1 inch in length, and lies in the groove between the great wing of the sphenoid and the apical portion of the petrous part of the temporal bone. It is at first narrow, but gradually enlarges, so as to resemble a trumpet. The narrowest portion of the whole tube is at the junction of the osseous and cartilaginous parts, this being known as the **isthmus,** and the widest part is at the pharyngeal orifice. The roof, inner wall, and upper part of the outer wall of the cartilaginous part consist of a triangular plate of cartilage, the margins of which are slightly rolled towards each other. The floor and most of the outer wall are formed of a dense fibrous membrane. The **pharyngeal orifice** of the tube is expanded, and is situated on the lateral wall of the naso-pharynx behind, and external to, the corresponding posterior naris, and on the same level as the posterior end of the inferior turbinate bone. It is somewhat oval, and presents, above and behind, a prominent border, formed by the thick margin of the cartilage, and called the **cushion.** Posterior to this is the lateral pharyngeal recess or fossa of Rosenmüller.

The tube is lined with mucous membrane, which is continuous with that of the tympanum on the one hand, and with that of the naso-pharynx on the other. It is thin in the osseous part of the tube, but in the cartilaginous part it is thick, and contains mucous

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glands and lymphoid tissue. It is covered by stratified columnar ciliated epithelium.

Muscles connected with the Eustachian Tube.—The **levator palati** has an origin from the lower margin of the cartilage of the tube, the **tensor palati** from the outer side of the cartilage, and the **salpingo-pharyngeus** is attached to the lower and front part of the tube. During deglutition the orifice of the tube is usually regarded as being kept open. According to Cleland, however, who had unusual opportunities of examining matters on the living person, 'the anatomical facts make it evident that any dilating influence of the tensor palati is exercised on the hinder and smaller part of the tube, whilst the levator palati closes the anterior (that is, pharyngeal) orifice' by raising the membranous floor of the tube.

Arteries.—These are derived from (1) the Vidian branch of the third part of the internal maxillary, and (2) the ascending pharyngeal branch of the external carotid.

Nerves.—The nerves are derived from (1) the tympanic plexus on the inner wall of the tympanum, and (2) the Vidian nerve.

Development.—The Eustachian tube is developed from the hypoblast of the first visceral cleft.

The Larynx.

The larynx is the upper part of the respiratory passage, being modified in structure so as to enable it to act as the organ of voice. It is situated in the median line of the neck above the trachea, and it lies opposite the fourth, fifth, and sixth cervical vertebræ. Superiorly it opens into the laryngeal portion of the pharynx, and inferiorly into the trachea. It is covered in front by the integument and the deep cervical fascia, and the laryngeal portion of the pharynx lies behind it. On either side it is in relation with the upper part of the lateral lobe of the thyroid body, the sterno-hyoid, omo-hyoid, sterno-thyroid, and thyro-hyoid muscles, and the common carotid artery.

Structure.—The larynx consists of a framework of cartilages, some of which are connected by joints and ligaments; it is provided with special muscles, spoken of as *intrinsic*; and it is lined with mucous membrane.

Cartilages.—These are nine in number, three being single and three arranged in pairs. The single cartilages are the epiglottis, the thyroid, and the cricoid, and the three arranged in pairs are the arytenoid, the cornicula laryngis, and the cuneiform.

The **epiglottis** is a leaf-like plate of yellow elastic fibro-cartilage, which stands bolt upright between the base of the tongue and the superior aperture of the larynx. Its lower part forms a narrow pedicle, which is attached to the receding angle of the thyroid cartilage, just below the median notch on its upper border, by means of a fibro-elastic band, called the **thyro-epiglottidean ligament.** Superiorly it presents a broad, round, free margin. Each lateral border is free above, but its lower part is contained within

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the aryteno-epiglottidean fold of mucous membrane. The anterior or lingual surface is free over its upper part, where it faces the base of the tongue, and is covered by mucous membrane. This membrane is prolonged on to the base of the tongue as the **glosso-epiglottidean fold,** or **frenum epiglottidis,** which is mesially placed. It is also prolonged from the sides of the epiglottis on to the lateral walls of the pharynx as the **pharyngo-epiglottidean folds.** On either side of the frenum epiglottidis, between it and each

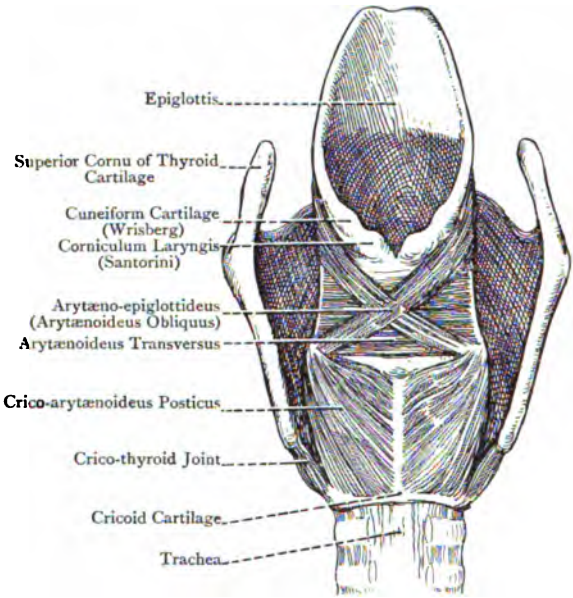

FIG. 506.—THE INTRINSIC MUSCLES OF THE LARYNX (POSTERIOR VIEW).

pharyngo-epiglottidean fold, there is a depression or fossa, which is known as the **vallecula.** Lower down than these folds the anterior surface is connected to the back of the upper border of the body of the hyoid bone by an elastic, semilunar membrane, called the **hyo-epiglottidean ligament.** Above the upper border of the thyroid cartilage the anterior surface is separated from the posterior aspect of the thyro-hyoid membrane by a collection of adipose and elastic tissues, which is known as the **periglottis** (epiglottidean gland). The posterior or laryngeal surface is free over its whole extent, and is covered by mucous membrane. It is concave from side to side, and concavo-convex from above downwards. The lower convexity forms the **cushion** or **pulvinar.** When the mucous membrane is removed the epiglottis presents a number of small glandular pits.

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Thyroid Cartilage.—This cartilage is composed of two flat quadrilateral **alæ,** which meet in front by their anterior borders, but diverge widely behind. The angular projection formed by their union is called the **isthmus** or *pomum Adami.* The union is confined to about the lower half of each anterior border, and there is left superiorly a deep triangular cleft called the **thyroid notch.** The posterior border, of greater length than the anterior, is round, and gives attachment to fibres of the palato-pharyngeus and stylo-pharyngeus muscles. At either extremity it is prolonged into a projection, the superior cornu and inferior cornu respectively. The **superior cornu** gives attachment to the lateral thyro-hyoid ligament, and the **inferior cornu,** which is slightly incurved, is facetted on its inner aspect to articulate with the cricoid cartilage. The superior border is for

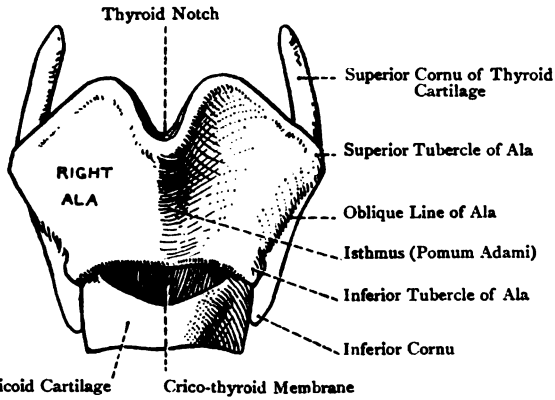

FIG. 507.—THE THYROID AND CRICOID CARTILAGES OF THE LARYNX (ANTERIOR VIEW).

the most part convex, and near its back part it presents a slight eminence, called the **superior tubercle.** The inferior border is almost horizontal, and presents an eminence about the junction of the posterior third with the anterior two-thirds, called the **inferior tubercle.** It gives attachment to the median portion of the crico-thyroid membrane and the crico-thyroid muscle. The outer surface of the ala is marked by an oblique line, or, it may be, ridge, which extends downwards and forwards from the superior to the inferior tubercle. This line gives insertion to the sterno-thyroid, and origin to the thyro-hyoid, muscles. It divides the outer surface into two unequal parts, an anterior three-fourths and a posterior fourth, the latter giving origin to fibres of the inferior constrictor muscle. The inner surface of the ala is smooth, slightly concave, and covered by mucous membrane. In the median line, behind the pomum Adami, there is a vertical depression known as the **receding angle.** Commencing just below the thyroid notch on the upper border and passing downwards, this region gives attachment to the

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following structures: (1) the thyro-epiglottidean ligament, (2) the superior thyro-arytenoid ligaments (false vocal cords), and (3) the inferior thyro-arytenoid ligaments (true vocal cords), in association with which are the fibres of the thyro-arytenoid muscles.

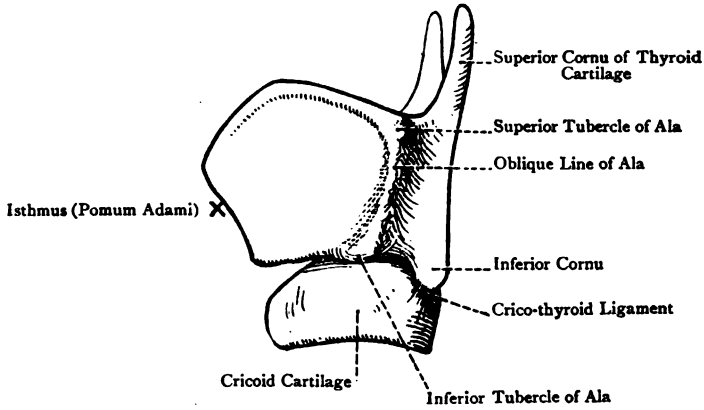

FIG. 508.—THE THYROID AND CRICOID CARTILAGES OF THE LARYNX (LATERAL VIEW).

Development of the Thyroid Cartilage.—The thyroid cartilage is regarded as being developed from the ventral portions of the skeletal cartilages of the fourth and fifth visceral arches of either side, which become united by a median plate. The cornua of each ala represents the ununited portions of the cartilages of the corresponding visceral arches, and the connecting median plate represents the isthmus.

Cricoid Cartilage.—This is situated below the thyroid cartilage, and indicates the lower limit of the larynx. As its name implies, it resembles a ring. Its anterior part is narrow, and is about $\frac{1}{5}$ inch in depth. The inferior border is horizontal, and is connected by membrane to the trachea. The superior border is connected anteriorly to the lower border of the thyroid cartilage by the median portion of the crico-thyroid membrane. Posteriorly this border presents a slight excavation at the centre, and at either side an oval convex facet for articulation with the base of the arytenoid cartilage. The posterior portion is deep, which is brought about by the rapid elevation of the superior border as it is traced backwards. The posterior surface is somewhat quadrilateral. It presents a median vertical ridge, the upper part of which gives attachment to the longitudinal muscular fibres of the œsophagus. This ridge divides

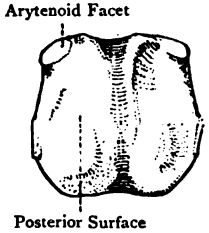

FIG. 509.—THE CRICOID CARTILAGE OF THE LARYNX (POSTERIOR VIEW).

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it into two symmetrical halves, each of which gives origin to the posterior crico-arytenoid muscle. The outer surface of the cricoid cartilage presents posteriorly a circular facet for articulation with the inferior cornu of the thyroid cartilage. The upper sloping border of this part gives attachment, along its inner margin, to the lateral portion of the crico-thyroid membrane. The inner surface of the cricoid cartilage is covered by the mucous membrane of the larynx. It is to be noted that the anterior narrow part of the cartilage stands quite clear of the thyroid cartilage, whereas the deep posterior part, where the upward elevation takes place, is received between the diverging alæ of the thyroid cartilage.

Development.—The cricoid cartilage, like the rings of the trachea, is developed in the mesoblast of the respiratory tube.

Arytenoid Cartilages.—These cartilages, which are two in number, surmount the superior border of the cricoid cartilage posteriorly. Each has the form of a three-sided pyramid, and measures about ½ inch in height, and about ¼ inch in width at the base. The apex looks upwards, and is curved in a backward and inward direction. It is surmounted by the corniculum laryngis. The base looks downwards, and is slightly concave and facetted to articulate with the superior border of the cricoid cartilage posteriorly. Two of the three angles of the base are prominent, namely, the anterior and the external. The **anterior angle,** somewhat pointed, is directed straight forwards, and is known as the *vocal process*. It gives attachment to the inferior thyro-arytenoid ligament or true vocal cord. The **external angle,** thick and somewhat round, has an inclination backwards, as well as outwards, and is known as the *muscular process*. Anteriorly it gives insertion to the crico-arytænoideus lateralis, and posteriorly to the crico-arytænoideus posticus. The surfaces are antero-external, posterior, and internal. The **antero-external surface,** a little above the vocal process, gives attachment to the superior thyro-arytenoid ligament or false vocal cord, and, above and external to the vocal process, to the thyro-arytænoideus muscle. The **posterior surface** is triangular and concave, and gives attachment to a portion of the arytænoideus muscle. The **internal surface** faces its fellow of the opposite side, and is covered by mucous membrane. It forms the posterior part of the lateral boundary of the rima glottidis. The borders are anterior, posterior, and external. The **anterior border** separates the internal from the antero-external surface, and terminates below in the vocal process. The **posterior border** separates the internal from the posterior surface.

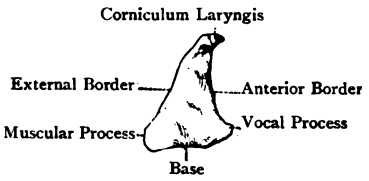

FIG. 510.—THE RIGHT ARYTENOID CARTILAGE AND CORNICULUM LARYNGIS (EXTERNAL VIEW).

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The **external border** separates the antero-external from the posterior surface, and terminates below in the muscular process.

The thyroid and cricoid cartilages usually retain their cartilaginous condition up to about the twentieth year. In the case of the thyroid cartilage ossification proceeds from the inferior cornu, there being a special osseous nucleus in the region of the pomum Adami.

The anterior part and lower margin of the cricoid cartilage remain cartilaginous for some time, but the remainder undergoes ossification simultaneously with the thyroid cartilage.

Ossification of the arytenoid cartilages takes place at a later date than in the case of the two preceding cartilages.

Cornicula Laryngis or Cartilages of Santorini.—These are two small, somewhat conical nodules of yellow elastic cartilage which cap the apical parts of the arytenoid cartilages, their direction being backwards and inwards. Each lies within the aryteno-epiglottidean fold of mucous membrane.

Cuneiform Cartilages or Cartilages of Wrisberg.—These are two nodules of yellow elastic cartilage, which are situated, one on either side, in the aryteno-epiglottidean fold of mucous membrane at its back part, not far from the cornicula laryngis.

Ligaments of the Larynx—Thyro-hyoid Membrane.—This is a broad membranous sheet, which passes between the superior border of the thyroid cartilage and the back of the upper border of the body of the hyoid bone, as well as the deep surface of each great cornu. Its central and lateral portions are strong, and are composed chiefly of elastic tissue. The central portion is known as the *middle thyro-hyoid ligament*, its lower attachment being to the margins of the thyroid notch. The lateral portions, round and cord-like, are very elastic, and are known as the *lateral thyro-hyoid ligaments*. Each extends from the superior cornu of the thyroid cartilage to the tip of the great cornu of the hyoid bone, and enclosed within it, towards its upper part, there is a small nodule of cartilage called the **cartilago triticea.** Between the upper median portion of the thyro-hyoid membrane and the concave posterior surface of the body of the hyoid bone there is a synovial bursa. It is to be noted that the superior attachment of the thyro-hyoid membrane is such as to enable the upper part of the thyroid cartilage, when raised, to be received within the outline of the hyoid bone. The central portion of the membrane is subcutaneous, but on either side it is covered by the thyro-hyoid muscle. Beneath the posterior border of this muscle the internal laryngeal nerve and superior laryngeal artery pierce this membrane.

Crico-thyroid Membrane.—This membrane is composed of a median and two lateral portions. The **median portion** is composed chiefly of elastic tissue, and is attached to the adjacent borders of the cricoid and thyroid cartilages. It is subcutaneous in the median line, but laterally it is overlapped by fibres of the crico-thyroid muscles. Its centre is crossed by the crico-thyroid arterial arch, formed by the crico-thyroid branches of the superior thyroid arteries, and it presents a few openings for the passage of blood-

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vessels. Through this portion laryngotomy may be performed. The **lateral portion** of the crico-thyroid membrane is connected below with the inner margin of the upper border of the lateral part of the cricoid cartilage. Superiorly it is not connected with the thyroid cartilage, but passes *within* its ala into the larynx, where it expands in an inward direction, and extends from the back of the ala of the thyroid cartilage in its lower part, close to the receding angle, to the under aspect of the vocal process of the arytenoid cartilage. Between these points it becomes continuous with the inferior thyro-arytenoid ligament or true vocal cord. The lateral portion of the crico-thyroid membrane (within the ala of the thyroid cartilage) is covered by the lateral crico-arytenoid and thyro-arytenoid muscles.

Superior Thyro-arytenoid Ligaments.—These form two small fibrous bands, one at either side, which lie within the folds of mucous membrane, called the false vocal cords. Each is attached

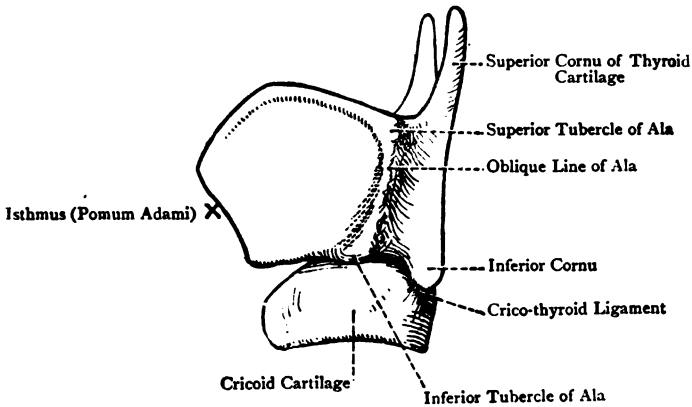

FIG. 511.—THE THYROID AND CRICOID CARTILAGES OF THE LARYNX (LATERAL VIEW).

in front to the receding angle of the thyroid cartilage immediately below the attachment of the thyro-epiglottidean ligament, and behind to the antero-external surface of the arytenoid cartilage a little above the vocal process.

Inferior Thyro-arytenoid Ligaments.—These important ligaments, covered by mucous membrane, constitute the true vocal cords, and each is continuous with the upper part of the expanded lateral portion of the crico-thyroid membrane. Each is composed of yellow elastic tissue, and, with its fellow, is attached in front to the receding angle of the thyroid cartilage at its centre, and behind to the vocal process of the arytenoid cartilage. Its inner border, which is covered by mucous membrane, is free and clearly

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defined. In its front part there is a small nodule of elastic cartilage called the *cartilage of Luschka* (Klein).

Crico-thyroid Joint.—This belongs to the class **diarthrosis.** The articular surfaces are the facet on the inner surface of the inferior cornu of the thyroid cartilage, and that on the outer surface of the cricoid cartilage posteriorly. The joint is surrounded by a capsular ligament, and this is lined with a synovial membrane. The **movements** allowed are as follows : (1) rotation of the thyroid cartilage round an axis passing transversely through both joints ; and (2) gliding, in which the cricoid moves upwards and backwards, or downwards and forwards, this movement partaking somewhat of a swinging character.

The recurrent laryngeal nerve ascends close behind the crico-thyroid joint preparatory to entering the larynx.

Crico-arytenoid Joint.—This belongs to the class **diarthrosis.** The articular surfaces are the convex facet on the superior border

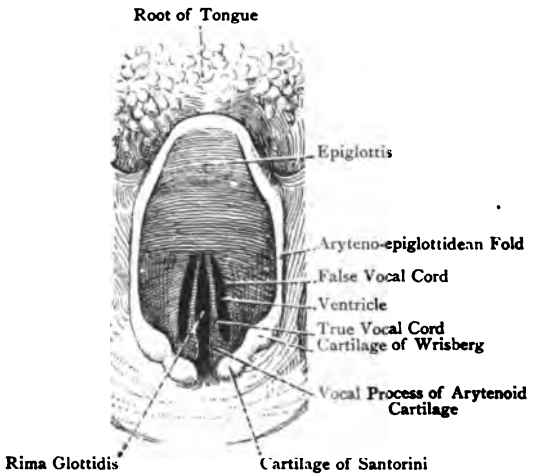

FIG. 512.—THE SUPERIOR APERTURE OF THE LARYNX AND ADJACENT PARTS.

of the cricoid cartilage posteriorly, and the concave under surface of the base of the arytenoid cartilage. The joint is surrounded by a capsular ligament, and this is lined with a synovial membrane. The **movements** allowed are as follows : (1) rotation, in which the arytenoid cartilage rotates on a nearly vertical axis, the effect being to invert, or evert, the vocal process; and (2) gliding in a lateral direction, in which one cartilage moves inwards towards its fellow, or outwards away from its fellow.

The cornicula laryngis are usually connected to the arytenoid cartilages by fibrous tissue, but in some cases there is a synovial articulation.

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Interior of the Larynx.—The **superior aperture of the larynx** is situated behind and below the epiglottis. It is triangular, being wide in front and narrow behind, and its plane is sloped obliquely downwards and backwards. Above and in front it is bounded by the epiglottis, and behind by the fold of mucous membrane which stretches between the arytenoid cartilages. On either side are the prominent aryteno-epiglottidean folds, which extend from the tips of the arytenoid cartilages to the sides of the epiglottis and contain muscular fibres. Each of these folds, close to the arytenoid cartilage, contains the corniculum laryngis or cartilage of Santorini, which gives rise to a slight elevation, and a little in front of this it presents another slight elevation produced by the cuneiform cartilage or cartilage of Wrisberg. Between the arytenoid cartilage and the back part of the aryteno-epiglottidean fold internally and the back part of the ala of the thyroid cartilage externally there is a depression, opening upwards, called the **sinus pyriformis.** In this depression a foreign body may become lodged.

The **interior of the larynx** commences at the superior aperture and terminates on a level with the lower border of the cricoid cartilage. It is divided into three compartments by means of two antero-posterior folds of mucous membrane, which project into it from each lateral wall. The upper pair of folds are called the false vocal cords, and the lower pair the true vocal cords. The upper compartment is known as the **vestibule,** and it extends from the superior aperture down to the level of the false vocal cords. It is wider above than below, and its anterior depth exceeds the posterior. The middle or **ventricular compartment** is situated between the false vocal cords above and the true vocal cords below. On either side it presents a recess, called the **ventricle of the larynx** or **laryngeal sinus.** This is bounded above by a false vocal cord, and below by a true vocal cord. Its outer wall is covered externally by fibres of the thyro-arytenoid muscle. At the anterior part of the ventricle there is a small valvular aperture, which leads to a diverticulum of the ventricle, called the **laryngeal saccule** or **pouch.** This extends upwards between the false vocal cord and the ala of the thyroid cartilage, reaching as high as the upper border of the latter. On its inner aspect there are some muscular fibres,

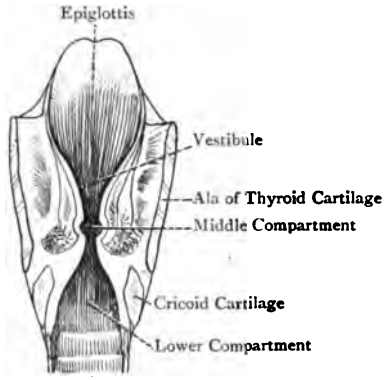

FIG. 513. — VERTICAL TRANSVERSE SECTION OF THE LARYNX, SHOWING THE POSTERIOR SURFACE OF THE ANTERIOR HALF OF THE ORGAN (MARSHALL).

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which are known as the compressor sacculis laryngis or Hilton's muscle.

The **lower compartment** of the larynx is compressed from side to side above, but becomes circular inferiorly, where it opens into the trachea.

Vocal Cords.—These are arranged in two pairs, laterally disposed, called false and true, or superior and inferior.

The **superior** or **false vocal cords** are two folds of mucous membrane, which extend at either side from the receding angle of the thyroid cartilage immediately below the attachment of the thyro-epiglottidean ligament to the antero-external surface of the arytenoid cartilage, a little above the vocal process. Each contains

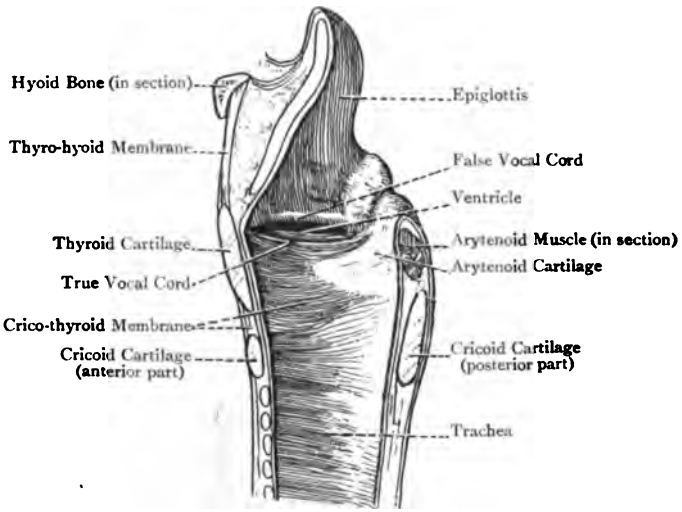

FIG. 514.—SAGITTAL SECTION OF THE LARYNX AND TRACHEA, SHOWING THE VOCAL CORDS AND VENTRICLE OF THE RIGHT SIDE.

some fibrous tissue forming the superior thyro-arytenoid ligament. The false vocal cords are widely separated from each other by an interval known as the *false glottis*, so that the true vocal cords are visible on looking into the larynx from above.

The **inferior** or **true vocal cords** are concerned in the production of the voice. They are prominent folds at either side, which are rather less than an inch in length, and extend from the receding angle of the thyroid cartilage to the vocal process of each arytenoid cartilage. Each cord consists of the inferior thyro-arytenoid ligament, which is continuous with the upper part of the expanded lateral portion of the crico-thyroid membrane, and is composed of yellow elastic tissue. The mucous membrane covering the cord is thin, and firmly adherent to the elastic tissue of the ligament,

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and it has a characteristic pearly white colour. The true vocal cords are much nearer to each other than the false, so that the latter are not visible when the larynx is viewed from below.

Rima Glottidis.—The rima glottidis, or *glottis vera*, is the narrow fissure by which the upper and lower compartments of the larynx communicate with each other, and it is the narrowest part of the cavity. It is elongated from before backwards, and is narrow in front at the receding angle of the thyroid cartilage, but wider behind, where it is closed by the interarytenoid fold of mucous membrane. It is divisible into an interchordal portion, called the *glottis vocalis*, and an interarytenoid portion, called the *glottis respiratoria*. The glottis vocalis is narrow, and is bounded on either side by the true vocal cord. Its length, as stated, is rather less than an inch, and it forms about two-thirds of the entire glottis.

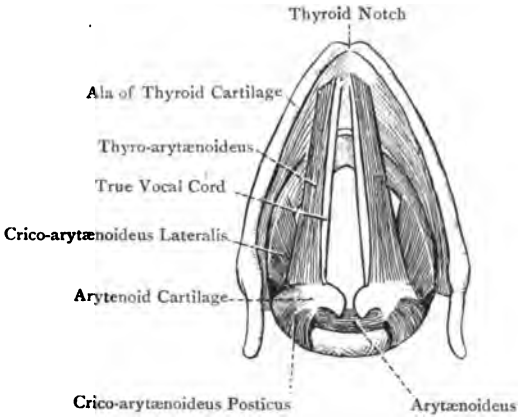

FIG. 515.—DISSECTION OF THE LARYNX, SHOWING THE MUSCLES, TRUE VOCAL CORDS, AND RIMA GLOTTIDIS (SUPERIOR VIEW).

The glottis respiratoria is wider than the glottis vocalis, and is bounded on either side by the inner aspect of the base of the arytenoid cartilage. It is about $\frac{1}{4}$ inch in length, and forms about one-third of the length of the entire glottis.

The shape of the rima glottidis is subject to alteration, and has to be considered under three conditions.

(1) During *quiet respiration* it has the form of an elongated triangle, the apex being in front at the thyroid cartilage, and the base behind at the interarytenoid fold of mucous membrane. (2) During a *deep inspiration* the rima is widely dilated, and assumes a somewhat diamond-shape, the widest part being opposite the tips of the vocal processes of the arytenoid cartilages, where the lateral angles of the diamond are placed, the posterior angle, at the interarytenoid fold of mucous membrane, being truncated. (3) During *vocalization*, *phonation*, and especially in *singing high*

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notes, the vocal cords become so closely approximated as to be practically parallel, and the glottis vocalis assumes the form of a narrow chink.

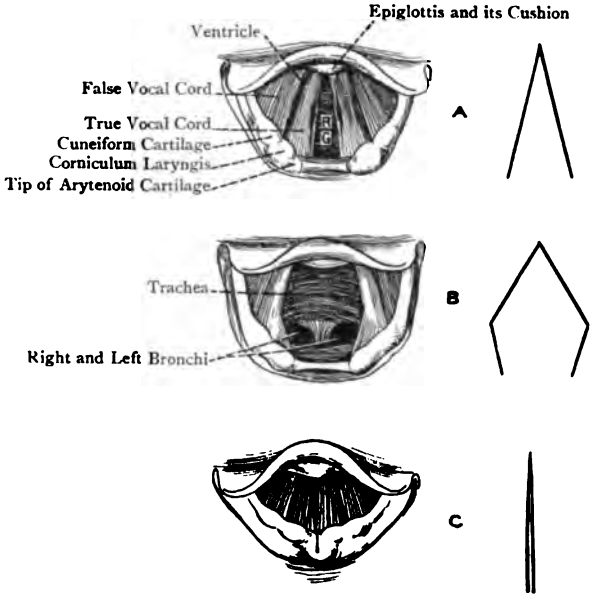

FIG. 516.—THE SUPERIOR APERTURE OF THE LARYNX AND THE RIMA GLOTTIDIS, AS SEEN BY THE AID OF THE LARYNGOSCOPE UNDER DIFFERENT CONDITIONS.

(The Figures on the left side are copied from Czermak).

A, Ordinary quiet inspiration
B, Very deep inspiration
C, Vocalization, especially in singing high notes
R.G. Rima Glottidis

Mucous Membrane of the Larynx.—This is continuous above with the mucous membrane of the pharynx, and below with that of the trachea. Above the level of the rima glottidis its subjacent attachment is of a loose nature on account of the presence of submucous areolar tissue, particularly in the vicinity of the aryteno-epiglottidean folds, a condition which favours the occurrence of œdema, but over the laryngeal surface of the epiglottis it is firmly attached. Over the true vocal cords it is very thin, and is firmly connected to the inferior thyro-arytenoid ligaments, which they contain. The membrane is covered by ciliated columnar epithelium, except (1) near the margin of the aryteno-epiglottidean folds, where it is of the stratified squamous variety, as in the laryngeal portion of the pharynx and the buccal cavity; and (2) over the true vocal cords, where it is also of the stratified squamous variety. Bodies resembling the taste-buds of the tongue are met with on the

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laryngeal surface of the epiglottis, the inner surfaces of the arytenoid cartilages and of the aryteno-epiglottidean folds, and over the margins of the false vocal cords.

The mucous membrane contains a large number of acinous mucous glands, the ducts of which open freely on the surface, except over the true vocal cords, where there are no glands. They are arranged in groups, as follows: (1) epiglottidean, which are very numerous, and occupy the pits on the laryngeal surface of the epiglottis; (2) arytenoidean, in front of the arytenoid cartilages, and in the adjacent portions of the aryteno-epiglottidean folds; (3) along the false vocal cords; and (4) in the wall of the laryngeal saccule, where they are very numerous.

Intrinsic Muscles.—These are the muscles by which the cartilages are moved upon each other so as to affect the condition of the

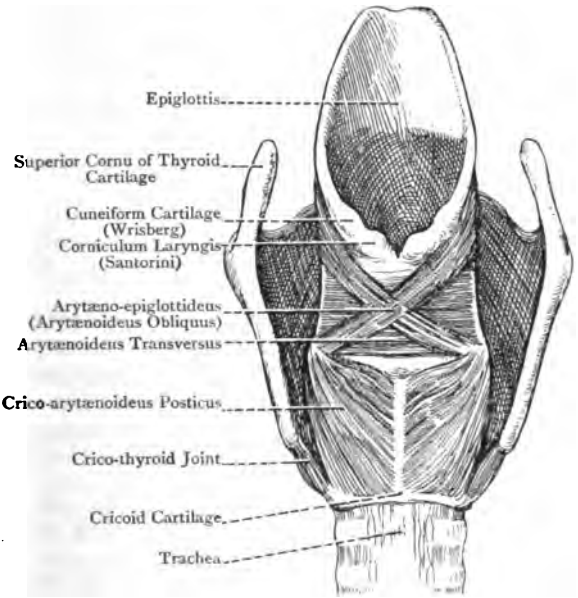

FIG. 517.—THE INTRINSIC MUSCLES OF THE LARYNX (POSTERIOR VIEW).

vocal cords. They are as follows: the crico-thyroid, posterior crico-arytenoid, lateral crico-arytenoid, arytenoid, and arytæno-epiglottideus. The arytenoid is a single muscle, but all the others are arranged in pairs.

Crico-thyroid—*Origin.*—The front of the anterior part of the cricoid cartilage, extending as far as the median line.

Insertion.—(1) The lower margin of the ala of the thyroid cartilage, and (2) the front of the inferior cornu.

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Nerve-supply.—The external laryngeal branch of the superior laryngeal nerve.

The fibres are directed upwards and backwards in a diverging manner, the posterior being horizontal and the anterior oblique. These two sets of fibres are usually distinct.

Action.—To approximate the front parts of the cricoid and thyroid cartilages in the following manner : the posterior horizontal fibres draw the cricoid cartilage backwards, and the anterior oblique fibres elevate the anterior part of the cricoid cartilage, thus imparting a swinging movement to the cartilage. As a result of this movement the deep posterior part of the cricoid cartilage, with the arytenoid cartilages on its upper border, are depressed. In this manner the vocal cords are put upon the stretch, so that the muscles are tensors of the cords.

Between the two muscles anteriorly there is a triangular interval about ½ inch wide, in which the central portion of the crico-thyroid membrane is visible, this portion being crossed at its centre by the crico-thyroid arch of arteries. In this region, just above the cricoid cartilage, laryngotomy may be performed.

Posterior Crico-arytenoid—*Origin.*—The posterior surface of the cricoid cartilage on one side of the median vertical ridge.

Insertion.—The posterior aspect of the muscular process or external angle of the base of the arytenoid cartilage.

Nerve-supply.—The recurrent laryngeal nerve.

The fibres of the muscle are directed upwards and outwards, the highest being short and nearly horizontal, the middle being oblique, and the lowest almost vertical.

Action.—To draw the muscular process of the arytenoid cartilage backwards and inwards, thereby swinging the vocal process or anterior angle outwards, the result of which is to open or widen the rima glottidis. The muscle is, therefore, a dilator of the rima glottidis.

The muscle is separated from its fellow by the median vertical ridge on the back of the cricoid cartilage.

Lateral Crico-arytenoid—*Origin.*—The lateral portion of the cricord cartilage along its upper sloping border, extending as far back as the crico-arytenoid joint.

Insertion.—The anterior aspect of the muscular process of the arytenoid cartilage, and the adjacent portion of the antero-external surface.

Nerve-supply.—The recurrent laryngeal nerve.

The fibres of the muscle are directed backwards and upwards.

Action.—To draw the muscular process of the arytenoid cartilage forwards and inwards, thereby swinging the vocal process or anterior angle inwards, the result of which is to narrow the rima glottidis. The two muscles, therefore, approximate and relax the true vocal cords, and they come into action in vocalization. When the posterior and lateral crico-arytenoid muscles act together they assist the arytenoid muscle in approximating the arytenoid carti-

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lages, and so the rima glottidis is closed. The lateral crico-arytenoid muscle is covered externally by the ala of the thyroid cartilage and the upper fibres of the crico-thyroid muscle, and internally by the lateral expanded portion of the crico-thyroid membrane.

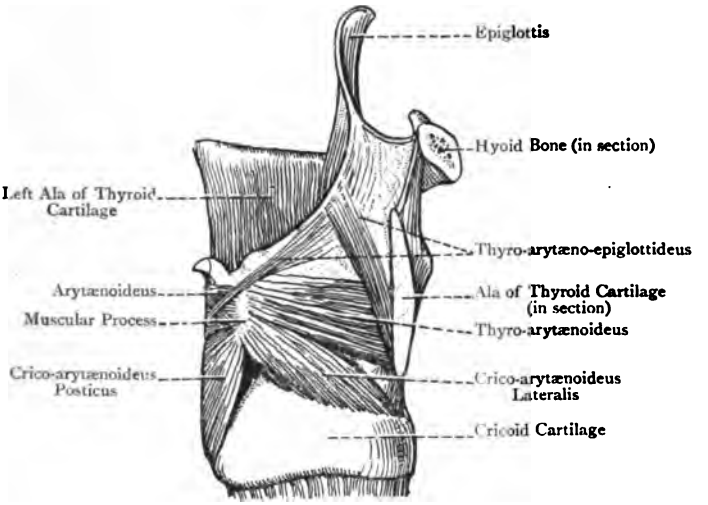

FIG. 518.—THE INTRINSIC MUSCLES OF THE LARYNX (LATERAL VIEW).

(The greater part of the Right Ala of the Thyroid Cartilage has been removed).

Thyro-arytenoid.—This muscle consists of two portions, external and internal.

External Portion — *Origin.*—(1) The lower half of the inner surface of the ala of the thyroid cartilage, and (2) the outer surface of the lateral portion of the crico-thyroid membrane.

Insertion.—The front of the muscular process and the adjacent part of the outer border of the arytenoid cartilage, a few of the fibres passing round the cartilage to become continuous with the arytænoideus. The uppermost fibres of this portion pass upwards and backwards to the aryteno-epiglottidean fold, and thence to the epiglottis, under the name of the **thyro-epiglottideus.**

Internal Portion—*Origin.*—(1) The receding angle of the thyroid cartilage, and (2) the cartilage of Luschka in the anterior part of the true vocal cord. According to Ludwig the deepest fibres of this portion, known as the **ary-vocalis,** spring from the anterior part of the true vocal cord.

Insertion.—The outer surface of the vocal process of the arytenoid cartilage, and the adjacent portion of the antero-external surface.

The fibres pass from before backwards, some of them having a slight inclination outwards, and the highest backwards.

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Nerve-supply.—The recurrent laryngeal nerve.

Action.—(1) **Internal Portion.** To draw forwards the arytenoid cartilage, and the posterior part of the cricoid cartilage, swinging the latter in an upward and forward direction. The result of this action is to relax the true vocal cords by approximating the arytenoid cartilage to the thyroid cartilage. This portion of the muscle is, therefore, the antagonist of the crico-thyroid. It is to be borne in mind, however, that one factor in relaxation of the true vocal cords must of necessity be elastic recoil. The fibres representing the ary-vocalis muscle of Ludwig act, according to him, by rendering tense that part of the true vocal cord which is in front of them, and relaxing the part behind them.

(2) **External Portion.** In virtue of its insertion into the muscular process of the arytenoid cartilage this portion will draw forwards that process, the effect of which is to swing inwards the vocal process. The fibres known as the thyro-epiglottideus have been supposed to assist in depressing the epiglottis.

The outer portion of the muscle lies within the ala of the thyroid cartilage. Its lower border is contiguous to the lateral crico-arytenoid, and its upper fibres lie on the outer wall of the ventricle and saccule. The inner portion of the muscle is in close contact with the outer side of the true vocal cord.

Arytenoid.—This is a single muscle, the fibres of which extend transversely from the posterior surface of one arytenoid cartilage to the posterior surface of the other. Some of the fibres are continuous with those of the external portion of the thyro-arytenoid muscle.

Nerve-supply.—The recurrent laryngeal nerve.

Action.—To draw the arytenoid cartilages together, so as to approximate the true vocal cords, and even close the rima glottidis.

The muscle, clothed with mucous membrane, bounds the rima glottidis posteriorly, and its superficial surface supports the obliquely decussating arytæno-epiglottidei muscles.

Arytæno-epiglottideus.—Each of these muscles, which has the form of a narrow slip or band, arises from the back of the muscular process of the arytenoid cartilage.

Its direction is upwards and inwards, and it decussates with its fellow of the opposite side, thus X. Having reached the summit of the opposite arytenoid cartilage, a few of the fibres terminate upon it, but the majority enter the corresponding aryteno-epiglottidean fold. Being reinforced by a few fibres from the summit of the arytenoid cartilage, they pass forwards within the fold to be inserted into the side of the epiglottis, in conjunction with those fibres of the thyro-arytenoid which are known as the thyro-epiglottideus.

Nerve-supply.—The recurrent laryngeal nerve.

Action.—The two muscles, having the two arytenoid cartilages within their embrace, sweep them together with the aid of the arytenoid muscle, and narrow the superior aperture of the larynx in the manner of a sphincter muscle.

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Compressor Sacculus Laryngis, or Hilton's Muscle.—This is the name given to a thin layer of muscular fibres on the inner side and upper end of the sacculus laryngis. The fibres are related superiorly to those of the arytæno-epiglottideus, which are contained within the aryteno-epiglottidean fold.

Summary of the Actions of the Laryngeal Muscles.—The intrinsic muscles of the larynx, by regulating the condition of the rima glottidis, contribute to vocalization, and modify the pitch of notes. In so doing they lengthen, so as to render tense, or shorten, so as to relax, the vocal cords; and they also bring the cords together, or draw them apart. In other words, the intrinsic muscles bring about *tension* and *parallelism* of the true vocal cords, or give rise to the opposite conditions, namely, *relaxation* and *divergence*.

Tension is effected by the crico-thyroid muscles, which swing the anterior part of the cricoid cartilage upwards and backwards towards the thyroid, the result being to increase the distance between the receding angle of the thyroid cartilage and the vocal processes of the arytenoid cartilages. In this manner the true vocal cords are stretched, and tension of them is produced.

Parallelism of the true vocal cords is effected by (1) the lateral crico-arytenoid muscles, and (2) the arytenoid muscle, the latter also producing narrowing of the glottis respiratoria (interarytenoid portion of glottis). The lateral crico-arytenoid muscles draw forwards the muscular processes of the arytenoid cartilages, the result of which is to swing inwards the vocal processes, and so produce parallelism. The arytenoid muscle draws the arytenoid cartilages together, and so narrows the glottis respiratoria, contributing at the same time to the condition of parallelism.

Relaxation of the true vocal cords is brought about by the thyro-arytenoid muscles, which draw the arytenoid cartilages, along with the posterior part of the cricoid cartilage, forwards. In this manner the distance between the receding angle of the thyroid cartilage and the arytenoid cartilages is diminished, and so relaxation of the true vocal cords is produced. They are at the same time shortened in virtue of their elastic recoil. The fibres of the thyro-arytenoid muscle, known as the ary-vocalis, act by rendering tense the part of the true vocal cord in front of them, and relaxing the part behind them (Ludwig).

Divergence of the true vocal cords and **opening of the rima glottidis** is effected by the posterior crico-arytenoid muscles, which draw the muscular processes of the arytenoid cartilages backwards and inwards, the result of which is to swing the vocal processes outwards. The actions of the intrinsic muscles may be tabulated thus:

Tension.	**Relaxation.**
Crico-thyroids.	Thyro-arytenoids.
Posterior crico-arytenoids.	Lateral crico-arytenoids.
Parallelism and Closure.	**Divergence and Opening.**
Lateral crico-arytenoids.	Posterior crico-arytenoids.
Arytenoid.	

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Function of the Epiglottis.—Two views are held as regards the function of the epiglottis. (1) According to one view it is folded down, like a lid, over the superior aperture of the larynx. This lid-like action is brought about by (*a*) the pressure exerted by the base of the tongue, (*b*) the action of the arytæno-epiglottidei muscles, and (*c*) the action of the thyro-hyoid muscles, which elevate the thyroid cartilage. (2) According to Stuart and M'Cormick the epiglottis is never folded down like a lid. The superior aperture of the larynx, according to these authorities, is closed by the action of the arytenoid and thyro-arytenoid muscles. The arytenoid muscle approximates the arytenoid cartilages, and the thyro-arytenoid muscles draw them forwards, so as to bring them into contact with the epiglottis.

The sphincter-like action of the arytæno-epiglottidei muscles upon the superior aperture of the larynx must, however, be taken into account.

Primâ facie the lid-like action appears to be the most natural one. The results, however, of ulceration of the epiglottis, and consequent loss of function, would tend to support Stuart and M'Cormick's view.

Nerves.—The nerves of the larynx are the superior and inferior, or recurrent, laryngeal, both of which are branches of the pneumogastric.

The **superior laryngeal nerve** divides into two branches, external and internal. The **external branch** (external laryngeal nerve), which is comparatively small, supplies the **crico-thyroid muscle,** and also furnishes twigs to the inferior constrictor muscle of the pharynx. The **internal branch** (internal laryngeal nerve), which is *sensory*, passes beneath the posterior border of the thyro-hyoid muscle, and enters the larynx by piercing the thyro-hyoid membrane, in company with the superior laryngeal artery, above which it lies. In the interior of the larynx it breaks up into branches, some of which ascend to the aryteno-epiglottidean fold and posterior surface of the epiglottis, a few of them passing through the latter to reach its anterior surface. The other branches descend to supply the laryngeal mucous membrane, and one of them joins a twig from the inferior or recurrent laryngeal nerve.

The **inferior** or **recurrent laryngeal nerve** is the principal *motor* nerve of the larynx. It passes beneath the lower border of the inferior constrictor muscle, and ascends upon the cricoid cartilage, lying close behind the crico-thyroid joint. Here it divides into two branches, anterior and posterior. The *anterior branch* ascends under cover of the thyroid cartilage, and is distributed to the lateral crico-arytenoid, thyro-arytenoid, thyro-epiglottideus, and aryteno-epiglottideus muscles. The *posterior branch* passes upwards on the back of the cricoid cartilage beneath the posterior crico-arytenoid muscle, which it supplies, and then it goes on to end in the arytenoid muscle.

The recurrent laryngeal nerve furnishes some *sensory* branches

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to the mucous membrane of the larynx below the rima glottidis, and it communicates with the internal branch of the superior laryngeal. The motor fibres of the external branch of the superior laryngeal and of the inferior laryngeal are derived from the bulbar portion of the spinal accessory nerve.

Summary of the Laryngeal Nerves.—The **superior laryngeal nerve,** through its **internal branch,** is *sensory*, and its **external branch** supplies the *crico-thyroid muscle*, and, in part, the inferior constrictor muscle of the pharynx.

The **inferior** or **recurrent laryngeal nerve** is chiefly *motor*, and it supplies the intrinsic muscles of the larynx, *with the single exception of the crico-thyroid muscle.*

Arteries.—The arteries of the larynx are the superior and the inferior laryngeal. The **superior laryngeal artery** is a branch of the superior thyroid. It accompanies the internal laryngeal nerve, below which it lies, and enters the larynx by piercing the thyro-hyoid membrane. The **inferior laryngeal artery** is a branch of the inferior thyroid, and it accompanies the inferior or recurrent laryngeal nerve.

Veins.—The **superior laryngeal vein** opens into the superior thyroid, and the **inferior laryngeal vein** into the inferior thyroid vein.

Lymphatics.—These are arranged in two sets—superior and inferior. The superior lymphatics come from the portion of the larynx above the rima glottidis. Having pierced the thyro-hyoid membrane, they pass to the upper group of deep cervical glands. The inferior lymphatics come from the portion of the larynx below the rima glottidis. Having pierced the crico-thyroid membrane, they pass to the lower group of deep cervical glands, having previously traversed the prelaryngeal glands.

In early life the larynx occupies a higher position than it does in the adult, its descent, which is gradual, being completed by puberty. Up to that period the projection known as the pomum Adami is not present. After puberty important changes take place. The cartilages increase in size, the pomum Adami assumes marked development, especially in the male, and the true vocal cords undergo increase in length. These various changes account for the modifications which the voice undergoes at and after puberty.

Development of the Larynx.—The larynx is developed from the upper part of a median diverticulum from the ventral aspect of the fore-gut, which diverticulum by its lower part gives rise to the trachea. The epiglottis, arytenoid cartilages, and aryteno-epiglottidean folds are developed from the *furcula*, which is an elevation, like a horseshoe, lying between the second, third, and fourth visceral arches of either side (see Fig. 491). The front part of the furcula gives origin to the epiglottis, the lateral parts to the aryteno-epiglottidean folds, and the back part (extremities of the horseshoe bend) to the arytenoid cartilages. The groove within the furcula represents the superior aperture of the larynx.

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Prevertebral Muscles.

Rectus Capitis Anticus Major—*Origin.*—By four short tendons from the tubercles of the costal processes (anterior tubercles of the transverse processes) of the third, fourth, fifth, and sixth cervical vertebræ, where it coincides with the origin of the scalenus anticus.

Insertion.—The inferior surface of the basilar process of the occipital bone, from the pharyngeal tubercle obliquely outwards and forwards for about ½ inch.

Nerve-supply.—The cervical plexus.

The muscle is directed upwards and inwards.

Action.—To flex the head.

Relations—*Anterior.*—The upper part of the common carotid, and the internal carotid, arteries, the internal jugular vein, the pneumogastric and sympathetic nerves, and the pharynx. *Posterior.*—A part of the longus colli, and a large portion of the rectus capitis anticus minor.

Rectus Capitis Anticus Minor—*Origin.*—The front of the root of the costal process of the atlas.

Insertion.—The inferior surface of the basilar process of the occipital bone, between the foramen magnum and the outer part of the insertion of the rectus capitis anticus major.

Nerve-supply.—The anterior primary division of the first cervical nerve.

The muscle is directed upwards and slightly inwards.

Action.—To flex the head.

Rectus Capitis Lateralis—*Origin.*—The upper aspect of the extremity of the transverse process of the atlas at its front part.

Insertion.—The inferior surface of the jugular process of the occipital bone.

Nerve-supply.—The anterior primary division of the first cervical nerve.

The muscle passes vertically upwards.

Action.—To flex the head to one side.

Longus Colli.—This complex muscle consists of three parts—upper oblique, vertical, and lower oblique.

Upper Oblique Part—*Origin.*—The fronts of the tubercles of the costal processes (anterior tubercles of the transverse processes) of the third, fourth, fifth, and sixth cervical vertebræ.

Insertion.—The lateral aspect of the anterior tubercle of the atlas.

The fibres are directed upwards and inwards.

Vertical Part—*Origin.*—The fronts of the bodies of the last two cervical and first three thoracic vertebræ.

Insertion.—The fronts of the bodies of the second, third, and fourth cervical vertebræ.

Lower Oblique Part—*Origin.*—The fronts of the bodies of the first three thoracic vertebræ in common with the lower portion of the vertical part.

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Insertion.—The fronts of the tubercles of the costal processes (anterior tubercles of the transverse processes) of the fifth and sixth cervical vertebræ.

Nerve-supply.—The anterior primary divisions of the adjacent spinal nerves.

Action.—To flex the cervical part of the vertebral column.

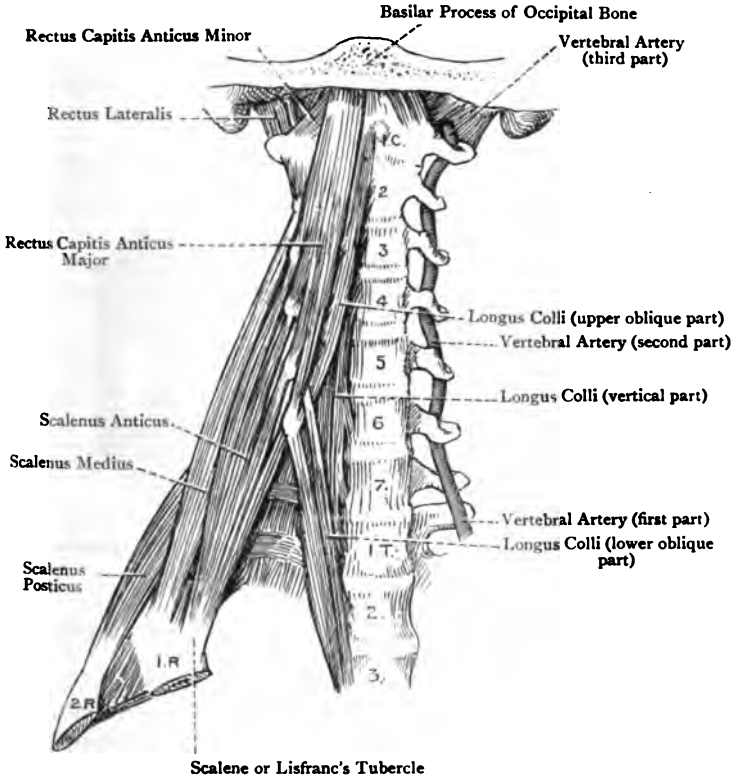

FIG. 519.—THE RIGHT PREVERTEBRAL MUSCLES.

(The Vertebral Artery is also shown).

Relations—*Anterior.*—The pharynx and œsophagus, the common and internal carotid arteries, and internal jugular vein ; the pneumogastric nerve, and the gangliated cord of the sympathetic ; the rectus capitis anticus major superiorly ; and the recurrent laryngeal nerve, inferior thyroid artery, and first part of the subclavian artery inferiorly. *Posterior.*—The bodies and discs of the adjacent vertebræ, and their transverse processes.

Petrous Part of the Internal Carotid Artery.—This part of the

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internal carotid artery is contained within the carotid canal of the petrous part of the temporal bone. It is at first directed upwards, and then, describing a bend, it passes forwards and inwards to the foramen lacerum medium, where it enters upon the cavernous part of its course. The vessel is surrounded by small tympanic veins, and is accompanied by the ascending branch of the superior cervical ganglion of the sympathetic nerve. This branch breaks up into two divisions. One of these lies on the outer side of the artery, and gives rise to the carotid sympathetic plexus, whilst the other lies on the inner side of the artery, and goes on to form the cavernous sympathetic plexus.

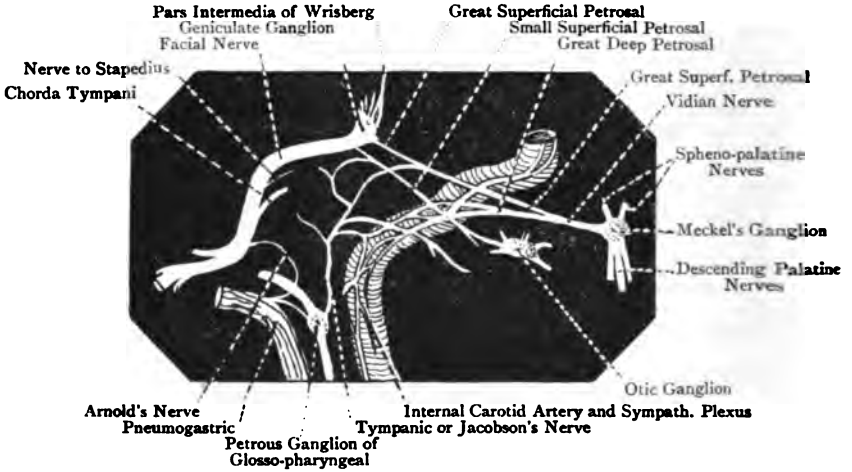

FIG. 520.—THE FACIAL NERVE IN THE AQUEDUCT OF FALLOPIUS, ETC. (HIRSCHFELD AND LEVEILLÉ).

As the artery ascends in the carotid canal it is situated in front of, and below, the tympanum and cochlea; as it bends it has the Eustachian tube on its anterior and outer side; and as it passes forwards and inwards it has the Gasserian ganglion above it, the partition between the two being for the most part membranous.

Branches.—The petrous part gives off a *tympanic branch* which enters the tympanum through the posterior wall of the carotid canal, and it may furnish a *petrosal branch* to accompany the great deep petrosal nerve.

For the cavernous part of the internal carotid artery, see p. 1003.

Petrous Part of the Facial Nerve.—This part of the nerve extends from the orifice of the meatus auditorius internus, on the posterior surface of the petrous part of the temporal bone, to the stylo-mastoid foramen, and it traverses (1) the meatus auditorius internus, and (2) the aqueduct of Fallopius.

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Meatal Portion.—This portion of the nerve is directed outwards, and is accompanied by the pars intermedia of Wrisberg, the auditory nerve, and the internal auditory artery. It is placed upon the upper and anterior aspect of the auditory nerve, and the pars intermedia lies between the two, and here joins the facial nerve. At the deep end of the internal auditory meatus the facial nerve parts company with the auditory nerve, and enters the aqueduct of Fallopius.

Branches.—Two branches connect the facial nerve with the auditory nerve.

Portion in the Aqueduct of Fallopius.—The direction of this portion of the nerve corresponds to that of the aqueduct. It may conveniently be divided into three stages—first, second, and third. In the *first stage*, which is very short, the nerve passes horizontally outwards, between the cochlea and vestibule, to the inner wall of the tympanum, where it presents an enlargement, called the **geniculate ganglion.** It then describes a sharp bend, and in the *second stage* passes backwards, lying above the fenestra ovalis. Thereafter it describes another abrupt bend, and in the *third stage* descends behind the posterior wall of the tympanum to the stylo-mastoid foramen, by which it escapes from the aqueduct. The *hiatus Fallopii* leads from near the commencement of the aqueduct to the superior surface of the *pars petrosa*. As the aqueduct descends it communicates with the canal of the pyramid of the tympanum, and below this it presents another opening, called the *iter chordæ posterius*.

Branches.—These are as follows :

From Geniculate Ganglion:
- Great superficial petrosal (to Meckel's ganglion).
- Communicating branch to small superficial petrosal (to the otic ganglion).
- External superficial petrosal (to sympathetic plexus on middle meningeal artery).

Nerve to the stapedius muscle.
Chorda tympani nerve.
Communicating branch to the auricular branch (Arnold's nerve) of the pneumogastric.

The **great superficial petrosal nerve** arises from the geniculate ganglion and passes forwards through the hiatus Fallopii, by which it emerges from the aqueduct of Fallopius. It then courses inwards and forwards in a groove on the superior surface of the petrous part of the temporal bone, and passes beneath the Gasserian ganglion to the foramen lacerum medium. In the upper part of this foramen it joins the great deep petrosal nerve from the carotid plexus to form the Vidian nerve, which passes forwards through the Vidian canal into the spheno-maxillary fossa, and joins the back part of Meckel's ganglion. The great superficial petrosal nerve contains some motor fibres, but to a large extent it consists of sensory fibres. These represent peripheral branches of the unipolar cells of the geniculate ganglion, the central branches of which give rise to the pars intermedia of Wrisberg.

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A **communicating branch** passes from the geniculate ganglion to the *small superficial petrosal nerve*, which latter represents the tympanic branch (Jacobson's nerve) of the glosso-pharyngeal, after it has emerged from the tympanic plexus on the inner wall of the tympanum. Through means of the small superficial petrosal nerve this communicating branch is conducted to the otic ganglion.

The **external superficial petrosal nerve** (sometimes absent) emerges at a point just within the orifice of the hiatus Fallopii, and passes to the sympathetic plexus around the middle meningeal artery.

The **nerve to the stapedius muscle** arises from the facial nerve in the descending part of the aqueduct of Fallopius, opposite the pyramid of the tympanum. It enters a small canal in the pyramid, and so reaches the stapedius as that muscle lies within the canal.

The **chorda tympani nerve** arises from the facial in the descending part of the aqueduct of Fallopius, a little above the stylo-mastoid foramen. It passes upwards and forwards in a somewhat recurrent manner through a minute canal, called the *iter chordæ posterius*, by which it enters the tympanum. At first it is placed on the posterior wall of the tympanum, close to the posterior margin of the membrana tympani, and on a lower level than the pyramid. The nerve then passes forwards upon the membrana tympani, near its upper margin, lying between its mucous and fibrous layers, so as to be ensheathed by the mucous membrane. In this part of its course it passes over the inner aspect of the handle of the malleus. Having arrived at the inner end of the fissure of Glaser, it leaves the tympanum by passing through the *iter chordæ anterius* or *canal of Huguier*. It then enters the pterygo-maxillary region, and passes downwards and forwards under cover of the external pterygoid muscle, where it receives a communicating twig from the otic ganglion, and thereafter joins the lingual nerve at an acute angle, under cover of the external pterygoid muscle. The subsequent distribution of the nerve has been already described (see p. 1167).

The chorda tympani is principally composed of fibres which are the peripheral processes of the unipolar cells of the geniculate ganglion of the facial nerve. These represent the fibres which are distributed to the sides and dorsum of the tongue over its anterior two-thirds. They are, therefore, regarded as *gustatory*, or pertaining to taste, and functionally are afferent. They belong to the same group of fibres as compose the pars intermedia of Wrisberg, which represent the central processes of the unipolar cells of the geniculate ganglion of the facial nerve. In other words, the greater portion of the chorda tympani and the pars intermedia are to be regarded as one nerve, with the unipolar cells of the geniculate ganglion interpolated in their course in the form of cell-stations. The chorda tympani nerve, however, also contains purely facial fibres, which are the secretory fibres of the submaxillary and sublingual glands. The nerve is, therefore, a mixed nerve.

A **communicating branch** is given off from the facial nerve, just

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above the stylo-mastoid foramen, which connects it with the auricular branch (Arnold's nerve) of the pneumogastric.

Pars Intermedia of Wrisberg.—The fibres of this small nerve arise from the unipolar cells of the geniculate ganglion of the facial, being the central processes of these cells, the peripheral processes representing the principal fibres of origin of the chorda tympani. The pars intermedia is at first closely incorporated with the facial nerve, and passes from the aqueduct of Fallopius into the internal auditory meatus. Here it separates from the facial nerve, and lies between it and the auditory nerve. After emerging through the orifice of the internal auditory meatus the pars intermedia passes to the lower border of the pons Varolii, where it enters the medulla oblongata, and terminates in the **fasciculus solitarius** and upper part of the glosso-pharyngeal nucleus.

The chorda tympani and the pars intermedia of Wrisberg, with the geniculate ganglion interpolated, may be regarded as representing the **afferent** or **sensory root** of the facial nerve.

Auditory Nerve in the Internal Auditory Meatus.—This nerve passes outwards in the internal auditory meatus in company with

FIG. 521.—SCHEME OF THE AUDITORY NERVE (FLOWER).

C.F. Communicating with Facial
C. Cochlear Nerve
V. Vestibular Nerve
S.S.C. To Superior Semicircular Canal
E.S.C. To External Semicircular Canal
U. To Utricle
S. To Saccule
P.S.C. To Posterior Semicircular Canal

the pars intermedia of Wrisberg, the facial nerve, and the internal auditory artery. The facial nerve is placed upon its upper and anterior aspect, and the pars intermedia lies between the two. Two branches connect the auditory nerve with the facial.

At the deep end of the meatus the auditory nerve breaks up into two divisions—an upper, called the vestibular nerve, and a lower, called the cochlear nerve. The **vestibular nerve** presents a ganglion, called the *ganglion of Scarpa*, which is situated at the deep end of the meatus, its bipolar cells giving origin to the vestibular fibres. Thereafter it breaks up into two parts, upper and lower. The **upper portion** furnishes branches which pass to the ampullæ of the superior and external semicircular canals, and to the utricle. These pass through the foramina of the *superior vestibular area* of the upper fossa of the *lamina cribrosa* at the deep end of the meatus. The **lower portion** supplies branches to the ampulla of the posterior semicircular canal and to the saccule. The former pass through the *foramen singulare* in the lower fossa of the lamina cribrosa, and the latter through the foramina of the *inferior vestibular area* of the lower fossa of the lamina cribrosa.

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The branches of the **cochlear nerve** pass through the foramina of the *cochlear area* of the lower fossa of the lamina cribrosa.

Summary of the Petrosal Nerves.—There are three superficial petrosal nerves, namely, great, small, and external; and there are two deep petrosal nerves, namely, great and small.

Superficial Petrosal Nerves.—The *great superficial petrosal nerve* is a branch of the geniculate ganglion of the facial in the aqueduct of Fallopius. After emerging from that aqueduct through the hiatus Fallopii, it passes to the upper part of the foramen lacerum medium. Here it joins the great deep petrosal nerve to form the Vidian nerve, which passes forwards through the Vidian canal into the spheno-maxillary fossa, and joins the back part of Meckel's ganglion.

The *small superficial petrosal nerve* issues from the tympanic plexus on the inner wall of the tympanum, and represents the continuation of the tympanic branch (nerve of Jacobson) of the petrous ganglion of the glosso-pharyngeal nerve. As it traverses a canal in the petrous portion of the temporal bone it is joined by a small branch from the geniculate ganglion of the facial. Emerging from this canal through the accessory hiatus, it passes through the canaliculus innominatus, when present, or through the fissure between the *pars petrosa* and great wing of the sphenoid, or sometimes through the foramen ovale, into the zygomatic fossa, where it joins the otic ganglion, close below the foramen ovale.

The *external superficial petrosal nerve* (inconstant) is a branch of the geniculate ganglion of the facial. It emerges from the petrous part of the temporal bone through a small opening (inconstant) close to the hiatus Fallopii, and joins the sympathetic plexus on the middle meningeal artery.

Deep Petrosal Nerves.—The *great deep petrosal nerve* is a branch of the carotid plexus of the sympathetic. It joins the great superficial petrosal in the upper part of the foramen lacerum medium to form the Vidian nerve, which, as stated, passes through the Vidian canal into the spheno-maxillary fossa, and joins the back part of Meckel's ganglion.

The *small deep petrosal nerve* is a branch of the tympanic plexus. It passes forwards within the processus cochleariformis to the upper part of the foramen lacerum medium, where it joins the carotid plexus of the sympathetic, and the great deep petrosal nerve, or, it may be, the great superficial petrosal nerve. In this manner some of its fibres pass in the Vidian nerve to Meckel's ganglion.

The Articulations of the Atlas, Axis, and Occipital Bone.

Atlanto-axial Joints.—These are three in number, and they belong to the class **diarthrosis.** One is mesially placed, the articular surfaces being the atlantal facet on the anterior surface of the odontoid process of the axis and the odontoid facet on the posterior surface of the anterior arch of the atlas. This joint belongs to the subdivision **trochoides** or **pivot-joint.** The other two are placed one on either side, the articular surfaces of each being the inferior articular process of the atlas and the corresponding superior articular process of the axis. These two joints belong to the subdivision **arthrodia.**

Ligaments.—These are as follows: the transverse ligament, the capsular ligaments, and the accessory ligaments. Besides these there are the anterior and posterior atlanto-axial ligaments, which are not directly related to any of the joints.

The **transverse ligament** is usually spoken of as the *transverse ligament of the atlas.* It represents the transverse portion of the cruciform ligament, to be presently referred to, and it constitutes

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a strong band, which is attached on either side to the tubercle on the inner aspect of the lateral mass of the atlas. It is arched backwards behind the odontoid process, and at the median line it is connected on its posterior aspect with the *crura* of the vertical portion of the cruciform ligament. Between the ligament and the odontoid process there is an extensive synovial membrane, which extends well over each lateral aspect of the process, so as to come very near another synovial membrane between the front of the process and the anterior arch of the atlas.

The **capsular ligaments** are loose sacs which surround the articulations between the inferior articular processes of the atlas and the superior articular processes of the axis.

The **accessory ligaments** are two in number—right and left. Each extends from the posterior surface of the body of the axis, close to

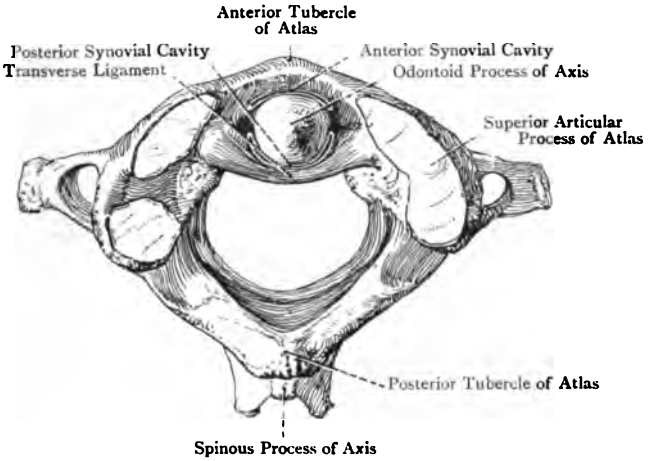

FIG. 522.—THE ARTICULATION BETWEEN THE ANTERIOR ARCH OF THE ATLAS AND THE ODONTOID PROCESS OF THE AXIS.

the root of the odontoid process, to the inner and posterior part of the lateral mass of the atlas. The direction of each ligament is upwards and outwards, and it is closely related superiorly to the capsular ligament, which it strengthens internally and posteriorly. The accessory ligaments are auxiliary in function to the check ligaments, and take part in limiting rotation of the atlas upon the axis.

The **anterior atlanto-axial ligament**, broad, thin, and membranous, is attached superiorly along the lower margin of the anterior arch of the atlas, and inferiorly to the anterior aspect of the body of the axis. It is serially continuous with the anterior common ligament of the bodies of the vertebræ, and its central portion is rendered thick by accessory fibres derived from the anterior common ligament.

The **posterior atlanto-axial ligament,** also broad, thin, and mem-

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branous, extends from the under aspect of the posterior arch of the atlas to the upper borders and adjacent portions of the outer surfaces of the laminæ of the axis. It is serially continuous with, and represents, the ligamenta subflava of succeeding vertebræ.

Atlanto-occipital Joints.—These are two in number, right and left. They belong to the class **diarthrosis** and to the subdivision **condylarthrosis.** The articular surfaces are the condyles of the occipital bone and the superior articular processes of the atlas.

Ligaments.—These are as follows: the capsular ligaments and the anterior and posterior occipito-atlantal ligaments, the latter two being indirectly connected with the joints.

The **capsular ligaments** are loose sacs which directly surround the articulations. Their fibres are attached superiorly around the margins of the occipital condyles, and inferiorly to the lateral

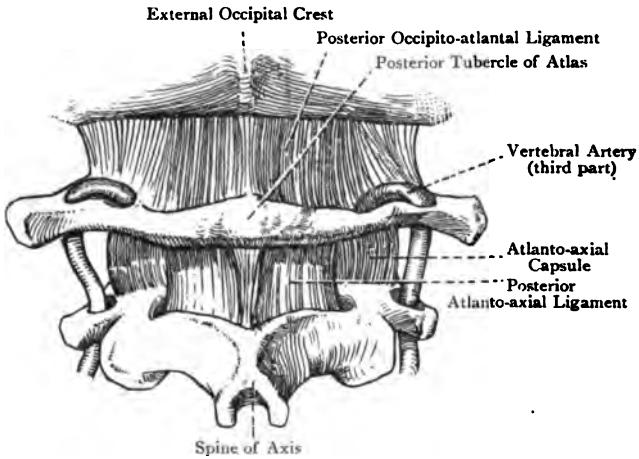

FIG. 523.—THE OCCIPITAL, ATLANTAL, AND AXIAL LIGAMENTS (SUPERFICIAL POSTERIOR VIEW).

masses of the atlas, external to the circumference of the superior articular processes.

The **anterior atlanto-occipital ligament,** thin and membranous, is attached inferiorly to the upper margin of the anterior arch of the atlas, and superiorly to the under surface of the basilar process of the occipital bone, close to the front part of the foramen magnum between the occipital condyles. In the median line it is rendered thick by the addition of a stout, round bundle of fibres, representing the *accessory ligament,* the fibres of which for the most part are attached below to the anterior tubercle of the atlas, but some of them are prolonged into the thickened anterior accessory part of the anterior atlanto-axial ligament.

The **posterior atlanto-occipital ligament,** broad, thin, and membranous, is attached inferiorly to the upper margin of the posterior arch of the atlas, except in the region of the vertebrarterial grooves,

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and superiorly to the lower margin of the foramen magnum behind the occipital condyles. Over each vertebrarterial groove of the atlas this ligament forms an arch, beneath which the vertebral artery and suboccipital nerve pass.

Occipito-axial Ligaments.—These are as follows: the posterior occipito-axial ligament; the lateral odontoid, or check, ligaments; the middle odontoid, or suspensory, ligament; and the vertical portion of the cruciform ligament.

The **posterior occipito-axial ligament**, also called the *membrana tectoria*, is a broad membranous band, which is attached inferiorly to the posterior surface of the body of the axis, where it is continuous with the fibres of the posterior common ligament of the bodies of the vertebræ, and superiorly to the posterior part of the

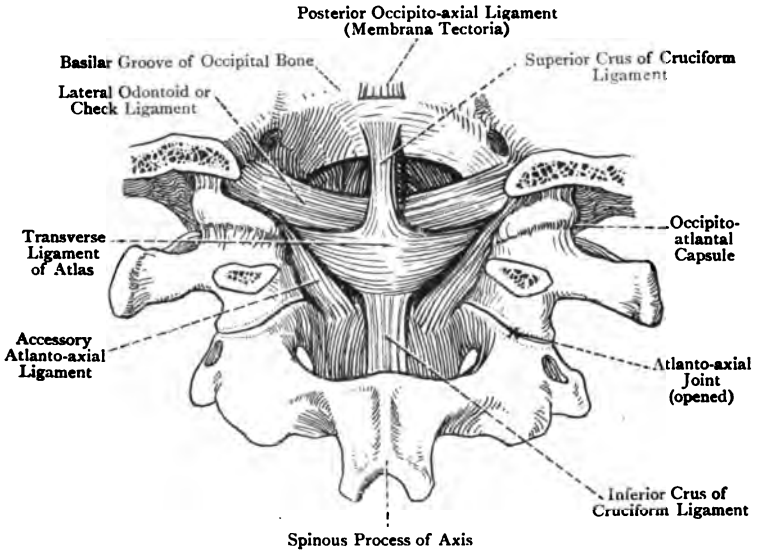

FIG. 524.—OCCIPITAL, ATLANTAL, AND AXIAL LIGAMENTS (POSTERIOR VIEW).

basilar groove of the occipital bone. It covers the odontoid process of the axis and the odontoid and cruciform ligaments, hence the name membrana tectoria.

The **vertical portion of the cruciform ligament** consists of two parts, upper and lower, which are spoken of as the superior crus and inferior crus. The *superior crus* extends from the posterior surface of the transverse ligament at the median line to the posterior part of the basilar groove of the occipital bone, between the anterior margin of the foramen magnum and the superior attachment of the membrana tectoria, under cover of which latter it lies. This crus, as it ascends, is in contact with the posterior surface of the head of the odontoid process. The *inferior crus* extends from the posterior surface of the transverse ligament at the median line

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to the posterior surface of the body of the axis above the inferior attachment of the membrana tectoria.

The **transverse portion of the cruciform ligament** constitutes the transverse ligament of the atlas, already described.

The **middle odontoid** or **suspensory ligament** is a narrow round cord which is attached inferiorly to the ridge on the head of the odontoid process, and superiorly to the anterior margin of the foramen magnum in the median line.

The **lateral odontoid** or **alar ligaments,** also known as the **check ligaments,** form two very strong bands which are attached inferiorly to the sloping surfaces on the head of the odontoid process, and superiorly to an impression on the inner surface of each con-

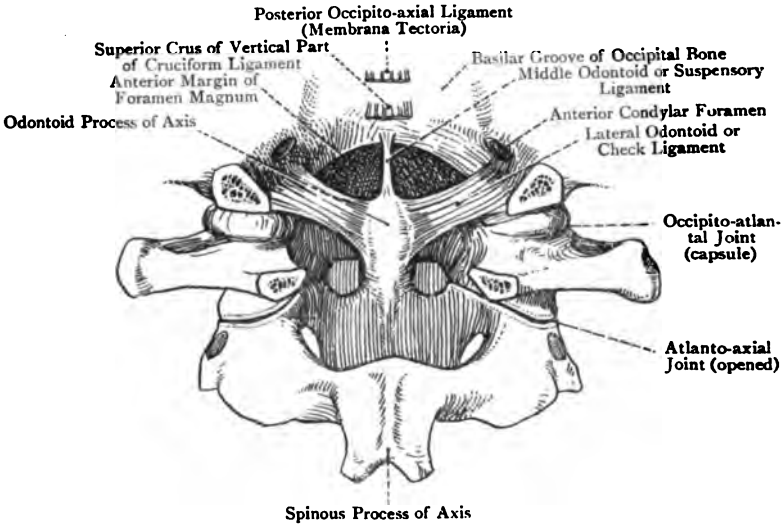
Posterior Occipito-axial Ligament
(Membrana Tectoria)
Superior Crus of Vertical Part of Cruciform Ligament
Anterior Margin of Foramen Magnum
Odontoid Process of Axis
Basilar Groove of Occipital Bone
Middle Odontoid or Suspensory Ligament
Anterior Condylar Foramen
Lateral Odontoid or Check Ligament
Occipito-atlantal Joint (capsule)
Atlanto-axial Joint (opened)
Spinous Process of Axis

FIG. 525.—THE OCCIPITAL, ATLANTAL, AND AXIAL LIGAMENTS (DEEP POSTERIOR VIEW).

dylar part of the occipital bone. The direction of each ligament is outwards and slightly upwards.

Movements—Atlanto-axial Joints.—The movements are of a *rotatory* kind, the altas, bearing the head, rotating on the axis, the odontoid process of which serves as a pivot. The extent of rotation is about 30 degrees, and it is limited by the lateral odontoid ligaments, aided slightly by the accessory atlanto-axial ligaments. The principal muscles concerned in rotation are the obliquus capitis inferior and rectus capitis posticus major of each side. **Atlanto-occipital Joints.**—The movements allowed at these joints are of a *nodding kind*, during which the head is depressed, so as to approximate the chin to the sternum, or raised to an erect position on the vertebral column, or even flexed in a backward direction. The principal muscles concerned in the nodding movements are the sterno-cleido-mastoids for forward depression, and the obliquus capitis superior, rectus capitis posticus minor, complexus, trachelo-mastoid, splenius capitis, and trapezius for the opposite movement.

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THE NERVOUS SYSTEM

THE nervous system is arranged in two divisions, cerebro-spinal and sympathetic.

The **sympathetic nervous system** consists of (1) two gangliated cords, right and left, situated on either side of the vertebral column, and (2) three prevertebral plexuses, namely, the cardiac plexus, situated in the thorax; the epigastric or solar plexus; and the hypogastric plexus, the latter two being situated in the abdomen.

The **cerebro-spinal nervous system** or **axis** consists of the encephalon and the spinal cord, the former being situated within the cranial cavity, and the latter within the spinal canal. The continuity between these two divisions is established through the foramen magnum.

The cerebro-spinal axis is central in position, and is connected with the various parts of the body by the cranial and spinal nerves. It is composed of two kinds of nervous matter, white and grey. The **white matter** consists chiefly of nerve-fibres, and the **grey matter** consists of nerve-cells, with their axis-cylinder processes or axons and dendrites, the pervading supporting tissue in each case being called **neuroglia.** In the brain the white matter is disposed in the interior as the *medulla*, and the grey matter forms the exterior or *cortex*. In the spinal cord the white matter is disposed externally in the form of three columns on either side, whilst the grey matter is situated in the interior.

The cerebro-spinal axis is surrounded by three membranes, or *meninges*, which, from without inwards, are named the dura mater, arachnoid membrane, and pia mater.

The Spinal Cord.

Membranes of the Spinal Cord.—The membranes are three in number, namely, the dura mater, the arachnoid membrane, and the pia mater.

Dura Mater.—This is the most external covering of the cord.

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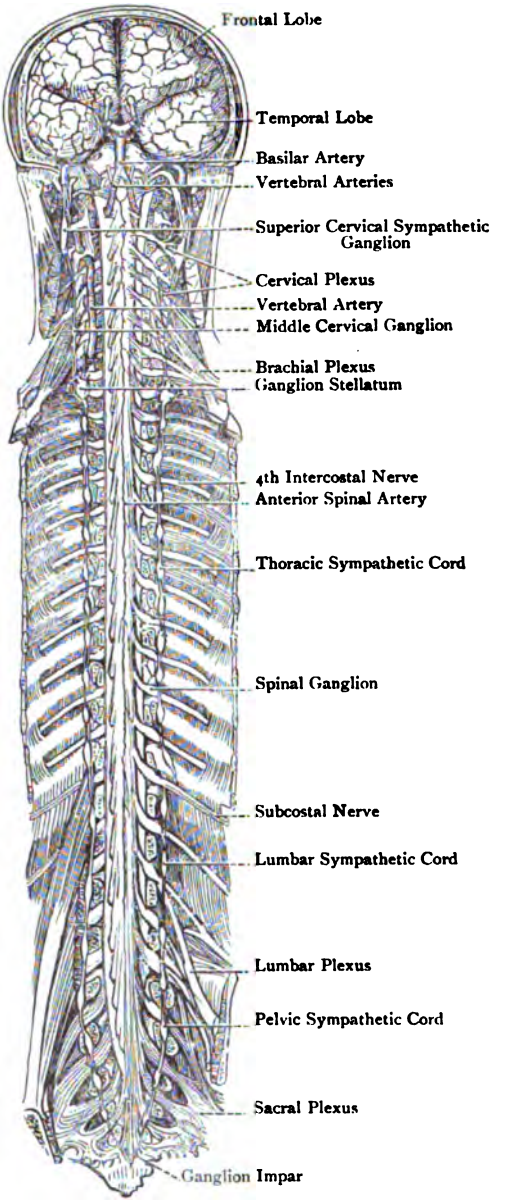

FIG. 526.—THE CEREBRO-SPINAL AND SYMPATHETIC SYSTEMS (ANTERIOR VIEW) (HIRSCHFELD AND LEVEILLÉ).

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It forms a firm fibrous tube, or *theca*, which extends from the margin of the foramen magnum to the back of the body of the second sacral segment. Superiorly it is continuous with the internal or sustentacular layer of the intracranial dura mater, the external layer of that membrane having blended with the occipital periosteum around the margin of the foramen magnum. The spinal dura mater, or theca, surrounds the spinal cord very loosely, and is separated from the walls of the spinal canal by an interval, known as the **epidural space,** which is occupied by venous plexuses and loose areolar tissue. The theca is prolonged, on either side, through the intervertebral foramina in the form of sheaths around the roots of the spinal nerves, which become continuous with their perineurium. It therefore presents on either side a series of openings, which are arranged in two parallel rows. The openings, constituting each pair, are placed side by side, but are distinct from each other, and they transmit the anterior and posterior roots of the spinal nerves.

The spinal dura mater differs from the intracranial dura mater in the following respects: (1) it is destitute of an outer or periosteal layer, and therefore does not form the periosteum of the spinal canal; (2) it does not send septa into the cord; and (3) it does not contain venous sinuses.

Blood-supply.—The arteries are derived from the spinal branches of the vertebral, deep cervical, intercostal, and lumbar vessels.

The lymph-spaces of the dura mater are in communication with those of the spinal nerves.

Nerve-supply.—The nerves are partly sympathetic and partly spinal.

Structure.—The dura mater consists of fibrous and elastic tissues, arranged as parallel longitudinal bundles. Its internal surface is covered by endothelial cells, which impart to it a smooth polished appearance.

Arachnoid Membrane.—This is a delicate membrane surrounding the spinal cord in the form of a tube which lies between the dura mater and pia mater. Superiorly it is continuous with the intracranial arachnoid, and it extends as low as the lower end of the theca. At either side it is prolonged before the processes of the ligamentum denticulatum. At the openings in the theca for the passage of the nerve-roots the endothelial cells covering the outer surface of the arachnoid become continuous with those which line the inner surface of the theca, and the remainder of the arachnoid blends with the perineurium of the nerves. Between the arachnoid and the dura mater there is a narrow interspace, called the **subdural space.** Between the arachnoid and the pia mater there is a wider interspace, called the **subarachnoid space.** At the back part of the spinal cord, in the median line, there is a membranous septum, incomplete above, called the *septum posticum*, which passes from the pia mater, as it crosses the posterior median fissure, to the contiguous part of the arachnoid. The ligamenta denticulata

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also constitute imperfect septa, on either side, in connection with the subarachnoid space.

The **subdural space** is the narrow interspace between the dura mater and the arachnoid. It is prolonged outwards for a short distance along the nerve-roots, and is in communication with the lymph-spaces of the nerves. It contains a small amount of fluid which moistens the opposed endothelial surfaces.

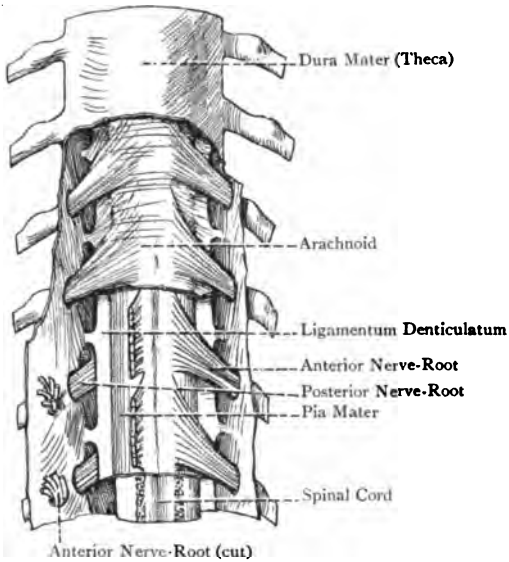

FIG. 527.—PORTION OF THE SPINAL CORD, SHOWING THE MEMBRANES, LIGAMENTA DENTICULATA, AND ROOTS OF THE SPINAL NERVES.

The **subarachnoid space** is the wide interspace between the arachnoid and the pia mater. It is crossed by delicate trabeculæ of connective tissue, which are arranged in a reticular manner, and the meshes of the reticulum contain cerebro-spinal fluid. It is continuous superiorly with the intracranial subarachnoid space (cisterna magna) and with the fourth ventricle of the brain through the foramen of Magendie and the foramina of Key and Retzius. On either side the subarachnoid space is incompletely divided into two compartments, anterior and posterior, by the corresponding ligamentum denticulatum; and posteriorly it is divided into two complete compartments, right and left, by the septum posticum, which, however, is incomplete above.

The subdural and subarachnoid spaces do not communicate with each other.

The nerves of the arachnoid are derived from the sympathetic system.

Structure of the Arachnoid Membrane.—The arachnoid consists of delicate bundles of fibrous tissue, which interlace with one another, and its external and internal surfaces are covered by endothelial cells.

Pia Mater.—This is the most internal covering of the spinal cord. It is a very vascular, fibrous membrane, and immediately invests

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the external surface of the cord, to which it is closely adherent. Superiorly it is continuous with the intracranial pia mater, and inferiorly it extends, in association with the filum terminale, to the back of the first coccygeal segment. On either side it is prolonged, in the form of tubular sheaths, around the nerve-roots, and ultimately blends with their perineurium. Along the course of the anterior median fissure of the cord it sends a distinct process into that fissure, and along the course of the posterior median fissure the neuroglial septum, which occupies that fissure, is attached to it. From its deep surface several processes are given off which enter the cord at different points, and penetrate into it to variable distances. Its external surface is connected with the arachnoid by the reticular trabeculæ which traverse the subarachnoid space, and by the septum posticum. Upon the external surface of the pia mater there are three thickened bands, namely, the linea splendens, and the two ligamenta denticulata.

The **linea splendens** is a glistening band which is situated on the anterior surface in the median line, where it lies over the anterior median fissure. Inferiorly it is continued upon the conus medullaris, and into the filum terminale.

The **ligamenta denticulata** are situated one on either side of the spinal cord. Each ligamentum denticulatum is a lateral extension of the fibrous element of the pia mater, and it connects that membrane with the dura mater. Its attachment to the pia mater forms an uninterrupted band which is situated between the anterior and posterior nerve-roots, and extends from a point above the first cervical, or suboccipital, nerve to the commencement of the conus medullaris, beyond which its fibres are continued into the filum terminale. Its attachment to the dura mater takes the form of distinct, pointed processes, which are fixed to it in the intervals between successive pairs of nerve-roots. These processes are triangular, and they impart a characteristic denticulate, or serrated, appearance to the ligament externally. Each process is covered by the arachnoid membrane, which is prolonged outwards before it. The number of denticulations is about twenty-one. The highest

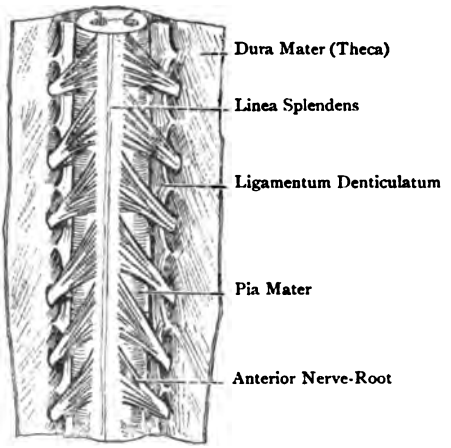

FIG. 528.—A PORTION OF THE SPINAL CORD (ANTERIOR VIEW).

(The Theca has been laid open, and the Arachnoid Membrane removed).

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is situated above the suboccipital nerve, and the lowest is usually placed between the twelfth thoracic and first lumbar nerves. The ligamenta denticulata serve to support the spinal cord within its theca of dura mater. As stated, they divide the subarachnoid space on either side into two incomplete compartments, anterior and posterior, the former being traversed by the anterior nerve-roots, and the latter by the posterior nerve-roots.

Blood-supply.—The pia mater is extremely vascular, and derives its blood from the spinal branches of the vertebral, deep cervical, intercostal, and lumbar arteries.

Nerve-supply.—The nerves are derived from the sympathetic system.

Lymphatics.—The lymphatics pass to the deep cervical, posterior

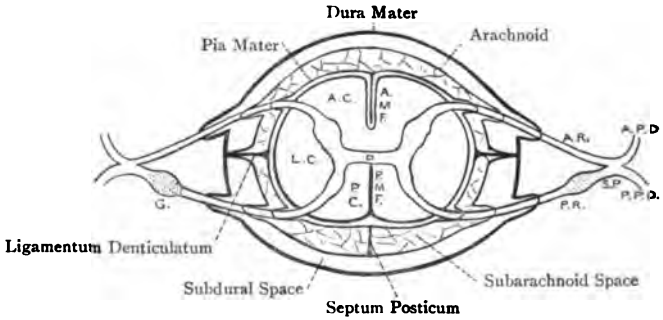

FIG. 529.—DIAGRAM OF A TRANSVERSE SECTION OF THE SPINAL CORD AND ITS MEMBRANES.

A.M.F. Anterior Median Fissure, with Process of Pia Mater
P.M.F. Posterior Median Fissure
A.C. Anterior Column
L.C. Lateral Column
P.C. Posterior Column
A.R. Anterior Nerve-Root
P.R. Posterior Nerve-Root
G. Spinal Ganglion
S.P. Spinal Nerve
A.P.D. Anterior Primary Division
P.P.D. Posterior Primary Division

intercostal, and lateral lumbar glands, which they reach through the intervertebral foramina.

Structure of the Pia Mater.—The pia mater consists of two layers, outer and inner. The *outer layer* consists of bundles of connective tissue, which are disposed for the most part longitudinally. The *inner layer* consists of areolar tissue, containing a great many bloodvessels, and its outer and inner surfaces are covered by endothelial cells. Lymphatic spaces occur at intervals between the two layers, and these spaces communicate with the subarachnoid space.

The spinal pia mater differs from the intracranial pia mater in being thicker and more adherent to the nervous substance. The greater thickness is due to the presence of the outer layer, the intracranial pia mater representing the inner layer of the spinal pia mater.

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External Characters of the Spinal Cord.—The spinal cord, or *medulla spinalis*, which is somewhat cylindrical, is that division of the cerebro-spinal axis which is situated within the spinal canal. It extends from the lower margin of the foramen magnum in the occipital bone to about the level of the disc between the bodies of the first and second lumbar vertebræ, and it is about 18 inches in length. Superiorly it is continuous with the medulla oblongata, and inferiorly it terminates in a tapering portion, called the **conus medullaris.** From the lower end of this cone a slender, glistening thread, called the **filum terminale,** is continued downwards between the bundles of lumbar, sacral, and coccygeal nerves of either side, which constitute the cauda equina, to be attached to the back of the first coccygeal segment.

The spinal cord is of smaller dimensions than the spinal canal, and is therefore relieved from pressure during the ordinary movements of the vertebral column. It is surrounded by three membranes, already described, namely, the dura mater, the arachnoid membrane, and the pia mater, in this order from without inwards. Within its theca of dura mater the cord is suspended by means of the ligamenta denticulata, and the nerve-roots as they emerge through the openings in the theca.

The spinal cord varies in shape in different regions. In the *cervical region,* as seen in transverse section, it is transversely oval, and is slightly flattened from before backwards. In the *thoracic region* it is somewhat circular, but the transverse diameter exceeds the antero-posterior. In the *lumbar region* it is still more circular than in the thoracic region.

The cord presents two swellings, which are known as the cervical and lumbar enlargements, and which are associated with the numerous and large nerve-trunks destined for the upper and lower limbs. The **cervical enlargement** extends from near the commencement of the cord to the second thoracic vertebra, and its breadth is greatest opposite the sixth cervical vertebra. The **lumbar enlargement,** which is less conspicuous than the cervical, extends from the level of the tenth thoracic vertebra to the conus medullaris, and its breadth is greatest opposite the twelfth thoracic vertebra.

Filum Terminale.—This delicate glistening thread is also known as the *central ligament* of the cord. It lies in the median line between the lumbar, sacral, and coccygeal nerves of either side, which constitute the cauda equina, and it extends from the apex of the conus medullaris to the back of the first coccygeal segment. It is about 6 inches in length. As low as the back of the body of the second sacral segment it is situated within the theca, but at that level it pierces the theca, from which it receives an investment, and then passes to be attached to the back of the first coccygeal segment, where it blends with the periosteum. For some distance the filum terminale contains in its centre a prolongation of the central canal of the spinal cord, which is surrounded by some of the

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grey matter. It is also composed of pia mater prolonged downwards from the conus medullaris, and reinforced by fibres derived from the lower portions of the ligamenta denticulata and linea splendens. Its lower part is purely fibrous.

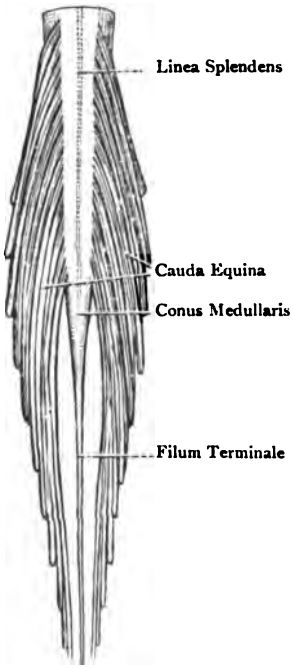

FIG. 530. — THE TERMINAL PART OF THE SPINAL CORD, AND THE CAUDA EQUINA.

Cauda Equina.—This is situated within the lower part of the theca. It consists of the lumbar, sacral, and coccygeal nerves of each side, which are arranged in the form of a leash, and the filum terminale lies in the median line between the two nerve-leashes. On account of the high origins of the individual nerves, relatively to the positions of the intervertebral foramina through which they pass, the direction of the nerves is almost vertical until they reach the level of their respective foramina of exit.

Fissures of the Spinal Cord.—The spinal cord, which is somewhat flattened in front and behind, is incompletely divided into two symmetrical halves by two median fissures, anterior and posterior. The **anterior median fissure** extends into the cord for one-third of its thickness from before backwards, and it contains a fold of the pia mater. At the bottom of the fissure the transverse band of nerve-fibres, called the *anterior white commissure*, crosses between the two halves of the cord. The **posterior median fissure**, though so named, is not an actual fissure like the anterior, and does not contain a fold of the pia mater. It is just wide enough to contain a septum formed by neuroglia, and it extends into the cord for about half of its thickness from before backwards. The *posterior grey commissure* lies at the bottom of the fissure. The anterior median fissure is more distinct and wider than the posterior, but it is not so deep.

Each half of the cord presents a groove along the line of entrance of the fasciculi of the posterior nerve-roots, called the **postero-lateral sulcus,** but there is no similar groove along the line of emergence of the fasciculi of the anterior nerve-roots, these being spread over an area of some breadth. By means of the postero-lateral sulcus on the one hand and the area corresponding to the emergence of the fasciculi of the anterior nerve roots on the other, each half of the spinal cord is divided superficially into three columns, anterior, lateral, and posterior.

The **anterior column** is situated between the anterior median

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fissure and the most external fasciculi of the anterior nerve-roots; the **lateral column** is the area between the most external fasciculi of the anterior nerve-roots and the postero-lateral sulcus; and the **posterior column** lies between the postero-lateral sulcus and the posterior median fissure. Practically the anterior column represents the region in front of the anterior nerve-roots, the lateral column the region between the anterior and posterior nerve-roots, and the posterior column the region behind the posterior nerve-roots. According to some authorities there are only two columns, namely, antero-lateral and posterior, the former extending from the anterior median fissure to the postero-lateral sulcus, and representing the combined anterior and lateral columns.

In the cervical region the surface of each posterior column presents a slight groove which is situated nearer the posterior median fissure than the postero-lateral sulcus. This groove is called the *posterior intermediate furrow*. It contains a septum of pia mater, and in this manner the posterior column of the cord is marked off into two tracts. The inner and smaller tract is called the **postero-median column,** or **column of Goll,** and the outer and larger is called the **postero-external column,** or **column of Burdach.** These two columns extend throughout the cord, but it is only above the level of the mid-thoracic region that they are separated from each other by a septum of pia mater, known as the *posterior intermediate septum.*

Origin of the Spinal Nerves. — There are thirty-one pairs of spinal nerves, which arise from the sides of the spinal cord. They are arranged in five groups, on either side, as follows: **cervical,** *eight* in number; **thoracic,** *twelve;* **lumbar,** *five;* **sacral,** *five;* and **coccygeal,** *one.* Each spinal nerve arises superficially from the cord by two roots, anterior and posterior, the posterior root being the larger of the two. The portion of the cord from which each pair of spinal nerves arise is spoken of as a *segment* of the cord. Each root is ensheathed by tubular prolongations of the coverings of the cord, namely, the pia mater, arachnoid, and dura mater, in this order from within outwards, and these sheaths ultimately blend with the perineurium. The roots are separated from each other by the lateral column of the cord and the ligamentum denticulatum, and they pass through separate openings in the theca of dura mater.

The **anterior roots** are composed of *efferent* or *motor fibres,* and their fasciculi emerge from the cord in an irregular manner, being spread over an area corresponding in breadth to the *caput* of the anterior cornu of the grey matter in the interior. The **posterior roots** are composed of *afferent* or *sensory fibres,* and their fasciculi enter the cord in a straight line along the course of the postero-lateral sulcus. Each posterior root presents an oval swelling, called the **spinal ganglion.** These ganglia are, for the most part, situated in the intervertebral foramina, and immediately beyond each ganglion the anterior and posterior roots unite to form

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a **spinal nerve,** which is necessarily a *mixed* nerve, inasmuch as it is composed of afferent and efferent fibres.

Each spinal nerve breaks up into an *anterior* and a *posterior primary division.*

The upper cervical nerve-roots are short, and pass almost horizontally outwards. The succeeding nerve-roots, however, gradually increase in length, and incline downwards as they pass outwards. This downward inclination goes on increasing until it becomes almost vertical in the case of the lumbar, sacral, and

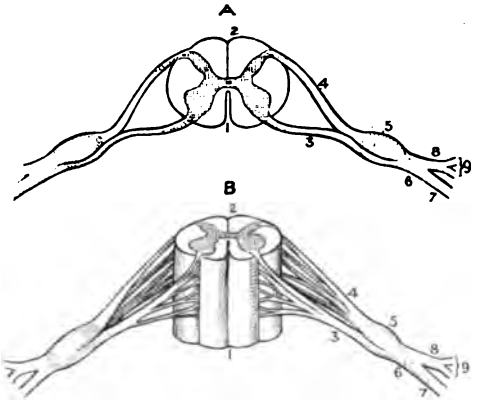

FIG. 531.—TWO SEGMENTS OF THE SPINAL CORD, SHOWING THE ATTACHMENTS OF THE ANTERIOR AND POSTERIOR NERVE-ROOTS, AND THE SPINAL GANGLIA.

A, Superior View; B, Anterior View.

1, 1. Anterior Median Fissure
2, 2. Posterior Median Fissure
3, 3. Anterior or Motor Nerve-Root
4, 4. Posterior or Sensory Nerve-Root
5, 5. Spinal Ganglion
6, 6. Spinal Nerve
7, 7. Anterior Primary Division
8, 8. Posterior Primary Division
9, 9. External and Internal Branches of Posterior Primary Division

coccygeal nerves, which constitute the cauda equina. From this disposition it follows that, in the majority of cases, the superficial origins of the spinal nerves are on a higher level than the intervertebral foramina through which they emerge from the spinal canal.

Relation of the Spines of Vertebræ to the Bodies and to the Origins of the Nerves.—In the case of the cervical and the eleventh and twelfth thoracic vertebræ the extremities of the spinous processes correspond to the lower margins of the bodies of the respective vertebræ. In the case of the thoracic vertebræ, from the first to the tenth inclusive, the extremity of each spinous process corresponds to the upper margin of the body immediately below. In the case of the lumbar vertebræ the extremity of each spinous process corresponds to the centre of the body of its own vertebra.

Each cervical spinous process is nearly opposite the lower fasciculi of the roots of the nerve below. The spinous process of the seventh cervical vertebra

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(vertebra prominens) is opposite the roots of the first thoracic nerve. From the third to the tenth thoracic vertebræ the spinous processes correspond to the second root below. The eleventh thoracic spine corresponds to the first and second lumbar nerves. The twelfth thoracic spine corresponds to the third, fourth, and fifth lumbar nerves. The first lumbar spine corresponds to the first, second, and third sacral nerves. (Gowers, from an original investigation).

Mode of distinguishing the Anterior and Posterior Surfaces of the Spinal Cord.—These surfaces may be recognised by attending to the following points :

Anterior Surface.	Posterior Surface.
1. Linea splendens in median line.	1. Ganglion on each posterior nerve-root.
2. Anterior spinal artery in median line.	2. Fasciculi of posterior nerve-roots lie in a straight line, and enter through postero-lateral sulcus.
3. Fasciculi of anterior nerve-roots spread over a wide area.	3. Arterial anastomotic chain behind and in front of the posterior nerve-roots.

Internal Structure of the Spinal Cord.—The spinal cord, as seen in transverse section, consists of a central portion composed of grey matter, and an external portion composed of white matter.

Grey Matter.—This is arranged in the form of two irregular crescents, the concavities of which are directed outwards, and the convexities inwards, the latter being connected across the middle line by the grey commissure. The arrangement has been likened to the letter ⋈. The **grey commissure** lies at the bottom of the posterior median fissure, and presents about its centre the minute opening of the central canal of the cord. The part of the commissure in front of this canal is known as the *anterior grey commissure*, and the part behind as the *posterior grey commissure*. In front of the anterior grey commissure there is a transverse band of white matter, called the **anterior white commissure,** which lies at the bottom of the anterior median fissure. Each crescent of grey matter consists of two cornua, anterior and posterior, the former being in front of, and the latter behind, the grey commissure. The **anterior cornu** is broad and blunt, and it stops short of the surface of the cord, being separated from the surface by white matter which is traversed by the fasciculi of the anterior nerve-roots. The blunt extremity of the anterior cornu is called the *caput cornu*, and the portion adjoining the grey commissure, which is slightly constricted, is called the *cervix cornu*. The **posterior cornu** is, for the most part, long, narrow, and tapering, and its pointed extremity almost reaches the surface of the cord at the bottom of the postero-lateral sulcus. This pointed extremity is called the *apex cornu*, and it contains a translucent substance, known as the **substantia gelatinosa of Rolando.** The portion adjoining the grey

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commissure, which is slightly constricted, is called the *cervix cornu*, and the portion contiguous to the cervix, which is slightly enlarged, is called the *caput cornu*.

About the centre of the concavity of each crescent the grey matter projects outwards into the lateral column in the form of processes arranged in a reticular manner and enclosing white matter. This network is called the **processus reticularis**, and it is most conspicuous in the cervical region. In the thoracic region, more particularly in its upper part, the grey matter of each crescent forms a triangular projection, which extends outwards for a short distance immediately in front of the processus reticularis, and adjacent to the junction of the anterior cornu with the grey com-

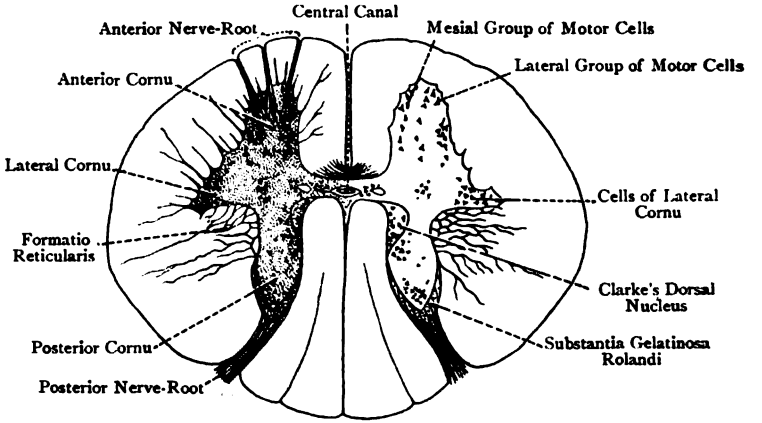

FIG. 532.—TRANSVERSE SECTION OF THE SPINAL CORD IN THE UPPER THORACIC REGION, SHOWING THE ARRANGEMENT OF THE GREY MATTER AND CELLS (SEMI-DIAGRAMMATIC) (AFTER POIRIER).

missure. This projection is variously known as the **lateral cornu**, the **intermedio-lateral tract of Lockhart Clarke**, or the **intermediate process of Gowers**. When followed into the lower cervical and into the lumbar regions it blends with the anterior cornu, the thickness of which it increases, but it is again present above the level of the fourth cervical vertebra.

The grey matter varies in amount in different parts of the cord. It is present in largest quantity in the lumbar enlargement, where the large nerve-trunks for the lower limbs arise, and next to this in the cervical enlargement, where the large nerve-trunks for the upper limbs arise.

The cornua of the crescents of grey matter vary in shape in different regions. In the cervical region the anterior cornua are short, broad, and blunt, and the posterior cornua are long, narrow, and pointed. In the thoracic region both cornua are narrow,

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though the posterior is more so than the anterior. In the lumbar region both cornua are broad, though the anterior is more so than the posterior. These differences render sections of the spinal cord in the cervical, thoracic, and lumbar regions easily recognisable. As stated, the lateral cornu is also a characteristic of the cord in the thoracic region, more particularly in its upper part.

Central Canal.—This minute canal is situated about the centre of the grey commissure, and extends throughout the entire length of the spinal cord. Superiorly it is continued into the lower half of the medulla oblongata, and it opens into the lower part of the fourth ventricle at the calamus scriptorius. Inferiorly, near the apex of the conus medullaris, it becomes enlarged, and assumes the shape of an inverted T, thus ⊥. This enlargement is known as the **ventriculus terminalis of Krause.** From this point it is prolonged for some distance into the filum terminale, and it ends in a closed extremity. In the cervical and thoracic regions the central canal

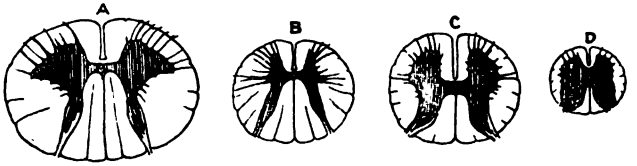

FIG. 533.—TRANSVERSE SECTIONS OF THE SPINAL CORD IN DIFFERENT REGIONS.

A, Cervical Region; B, Mid-thoracic Region; C, Lumbar Region; D, Conus Medullaris.

is nearer the anterior surface of the cord than the posterior, but in the lumbar region it occupies the centre. In the conus medullaris it is near the posterior surface.

The canal is lined with ciliated columnar epithelium, the columnar cells being known as ependymal cells.

The central canal represents the lumen of the neural tube of epiblast from which the spinal cord is developed.

White Matter of the Spinal Cord.—The white matter forms the outer part of the cord, and is arranged in three columns, anterior, lateral, and posterior. The **anterior column** is situated between the anterior median fissure and the anterior cornu of grey matter, and extends as far as the most external fasciculi of the anterior nerve-roots. It therefore includes the superficial coating of the anterior cornu, where it is traversed, over an area of some breadth, by the scattered fasciculi of the anterior nerve-roots. The **lateral column** is situated between the anterior and posterior cornua of grey matter, in the concavity of the crescent. Its superficial limits are the most external fasciculi of the anterior nerve-roots and the fasciculi of the posterior nerve-roots at the postero-lateral sulcus.

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The **posterior column** is situated between the posterior median fissure and the posterior cornu of grey matter, its superficial limit being the fasciculi of the posterior nerve-roots at the postero-lateral sulcus.

The white matter increases in quantity from below upwards, and septa of pia mater and neuroglia pass into it at various points.

Chief Distinguishing Characters of the Spinal Cord in Different Regions, as seen in Transverse Sections.

Cervical Region.	Thoracic Region.	Lumbar Region.
1. Transversely oval.	1. Approaching to circular.	1. Almost circular.
2. Anterior Cornu, short, broad, and blunt. Posterior Cornu, long, narrow, and tapering.	2. Anterior and Posterior Cornua both narrow, posterior more so than anterior.	2. Anterior and Posterior Cornua both broad, anterior more so than posterior.
3. Formatio Reticularis, well marked.	3. Formatio Reticularis, not very distinct.	3. Formatio Reticularis, absent.
4. Lateral Cornu, merged into anterior, except above fourth cervical vertebra.	4. Lateral Cornu, conspicuous, especially in upper part.	4. Lateral Cornu, merged into anterior.
5. White Matter, large in amount.	5. White Matter, less in amount, but large in proportion to Grey Matter.	5. White Matter, small in amount, and Grey Matter, large.
6. Central Canal, nearer the ventral than the dorsal surface.	6. Central Canal, nearer the ventral than the dorsal surface.	6. Central Canal, in the centre.
7. Postero-intermediate Sulcus and Septum of pia mater, well marked.	7. Postero-intermediate Sulcus, absent, but Septum of pia mater recognisable.	7. Postero-intermediate Sulcus and Septum of pia mater, absent.

Minute Structure of the Spinal Cord—Grey Matter.—The grey matter consists of nerve-cells, nerve-fibres, and neuroglia, and is very vascular.

The **nerve-cells** are present in great numbers, and are multipolar. Each cell sends off at various points several protoplasmic processes, one of which becomes the axis-cylinder of a nerve-fibre, and is called the *axis-cylinder process*, or *axon*. The other processes are known as the *protoplasmic processes of Deiters*, or *dendrites*, and, after successive branchings, they terminate in free extremities. There are no anastomoses between the dendrites of the same cell, nor between those of contiguous cells. A multipolar nerve-cell, with its axon and dendrites, constitutes a *neuron*. The multipolar

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cells form longitudinal columns of various lengths, and, as seen in transverse sections of the cord, they are arranged in groups which occupy particular regions. These cell-columns or groups are three in number, namely, anterior or ventral, in the anterior cornu of grey matter; lateral, in the lateral cornu of grey matter; and posterior, constituting the posterior vesicular column of Lockhart Clarke, and being very conspicuous in the mesial portion of the cervix of the posterior grey cornu in the thoracic region. Besides these main columns or groups, other nerve-cells are present, which are scattered irregularly throughout the other portions of the grey matter.

The **anterior** or **ventral cell-column** is situated, as stated, in the anterior cornu of grey matter, and extends throughout the

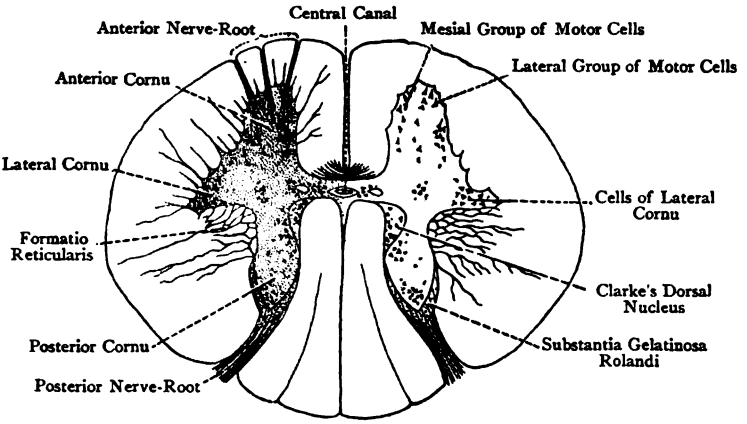

FIG. 534.—TRANSVERSE SECTION OF THE SPINAL CORD IN THE UPPER THORACIC REGION, SHOWING THE ARRANGEMENT OF THE GREY MATTER AND CELLS (SEMI-DIAGRAMMATIC) (AFTER POIRIER).

whole length of the spinal cord. Its cells are of large size and very conspicuous, and their axons, which are at first non-medullated, become medullated, and then constitute the fasciculi which emerge to form the anterior nerve-roots. These cells are therefore the sources from which the efferent or motor nerve-fibres proceed, and the ventral column is consequently spoken of as the **motor** or **ganglionic column.** The ventral or motor cells of this column are arranged in two groups, mesial and lateral. The *mesial group* occupies the mesial part of the anterior grey cornu, and the *lateral group* is situated in its outer part. In the cervical and lumbar enlargements of the cord the cells of the lateral group are very numerous, and are arranged in two sub-groups, ventro-lateral and dorso-lateral.

The **intermedio-lateral cell-column** is situated, as stated, in the

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lateral cornu of grey matter, and is conspicuous only in the thoracic region, more particularly in the upper part. In other regions, though present, this group is not very distinct, and its cells are comparatively small.

The **posterior vesicular cell-column** is situated, as stated, in the mesial portion of the cervix of the posterior grey cornu, and is known as **Clarke's column.** Being chiefly confined to the thoracic region, it has been called the *dorsal nucleus of Stilling.* It extends from the eighth cervical nerve to the second lumbar, and its cells are of large size and very conspicuous. Their axons pass into the lateral column of white matter, where they form the direct cerebellar tract.

The cells of the grey matter are of three kinds, namely, the cells of Golgi, the root-cells, and the strand-cells. The *cells of Golgi* have short axons which do not leave the grey matter, but pass between adjacent cells, and so bring them into communication with one another. The *root-cells* have long axons, which leave the cord as efferent or motor fibres, as in the cells of the anterior grey cornu. The *strand-cells* also have long axons which form certain tracts or strands in the cord, as in Clarke's column.

The **nerve-fibres** are both medullated and non-medullated, and are present in every part of the grey matter, in which they form a close interlacement.

Grey Commissure.—This is composed of medullated nerve-fibres, which are of the nature of transverse commissural fibres extending between the cells of the posterior grey cornua. It contains the central canal of the cord, which is situated rather nearer the front than the back. The area immediately around the canal is free from nerve-fibres, and consists of a substance called the substantia gelatinosa centralis.

Varieties of Grey Matter.—There are two kinds of grey matter, namely, the substantia gelatinosa of Rolando, and the substantia gelatinosa centralis. The **substantia gelatinosa of Rolando,** as previously stated, is situated in the apex of the posterior grey cornu, and it contains many nerve-cells, but little neuroglia. The **substantia gelatinosa centralis,** as just stated, is situated around the central canal, and it consists of neuroglia and processes from the deep or outer ends of the columnar cells which line the central canal.

White Matter.—The white matter of the cord consists of nerve-fibres and neuroglia. The fibres are of the medullated variety, but each is destitute of a primitive sheath or neurilemma.

Anterior White Commissure.—This consists of medullated nerve-fibres. Some of them pass across transversely, but many are disposed obliquely, so that a decussation takes place. On either side they enter the anterior grey cornu and anterior column of white matter. The fibres are derived from the following sources: (1) the direct pyramidal tract; (2) some fibres of the anterior nerve-roots; and (3) fibres of the spino-thalamic tract, to be presently described.

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Neuroglia of the Spinal Cord.—The neuroglia is the general supporting tissue of the grey and white matter, and has been so named from its apparent resemblance to glue, but it really consists of a horny substance, called *neuro-keratin*. It is composed of many cells, known as **glia-cells,** and a great number of delicate, branching fibres. The glia-cells are characterized by numerous branching processes, which constitute the **neuroglial fibres.** These fibres pervade the entire thickness of the cord, and interlace very freely with one another. On the surface of the cord the neuroglia forms a distinct layer beneath the pia mater, and from this layer processes are prolonged into the cord along with the septa of pia mater.

In early life the columnar cells which line the central canal send into the cord branching, filiform processes from their deep or outer ends.

Development.—The neuroglia is of epiblastic origin, and is developed from the spongioblasts of the neural tube, as are also the columnar cells (ependyma) which line the central canal.

Course of Nerve-fibres in the Cord — Anterior Nerve-roots.—The fibres of the anterior nerve-roots, having passed through the white matter of the anterior column, enter the anterior grey cornu. Thereafter some pass inwards, others outwards, whilst a third set pass backwards. The fibres which pass *inwards* end in one of two ways: (1) most of them become the chief processes or axons of the mesial group of cells in the anterior grey cornu of the same side; and (2) a few of them pass across in the anterior white commissure to the anterior grey cornu of the opposite side, where they become connected with its mesial group of cells. The fibres which pass *outwards* become the axons of the cells of the lateral group in the anterior grey cornu of the same side. The fibres which pass backwards enter the posterior grey cornu of the same side, and become connected with some of its cells. The fibres of the anterior nerve-roots are therefore principally confined to that side of the cord from which they emerge, and the *deep origin* of each fibre is a multipolar cell of the anterior grey cornu, of which cell it constitutes the chief process or axon.

Posterior Nerve-roots.—The fibres of the posterior nerve-roots have their origin in the unipolar cells of the spinal ganglia of the posterior nerve-roots. The single pole or process of each of these cells is T-shaped. One half of the horizontal limb of the T passes into the cord, and the other half passes outwards in the course of the nerve. Within the cord some of the fibres enter the caput cornu posterioris, others enter the postero-lateral column or column of Burdach, whilst those of a third set enter the tract of Lissauer. Each fibre divides into two branches, ascending and descending. The *descending branch*, after a short course, ends in an arborization around one of the cells of the posterior grey cornu. The chief process of that cell represents a new axon which passes forwards to the anterior grey cornu, where it ends in an

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arborization around one of the anterior or motor cells. The *ascending branch* represents the principal part of the fibre. In its upward course it gives off collaterals, which are disposed in three ways. (1) Some terminate in arborizations around the cells of the anterior cornu, which they reach in part directly, and partly through the intervention of the cells of the posterior grey cornu

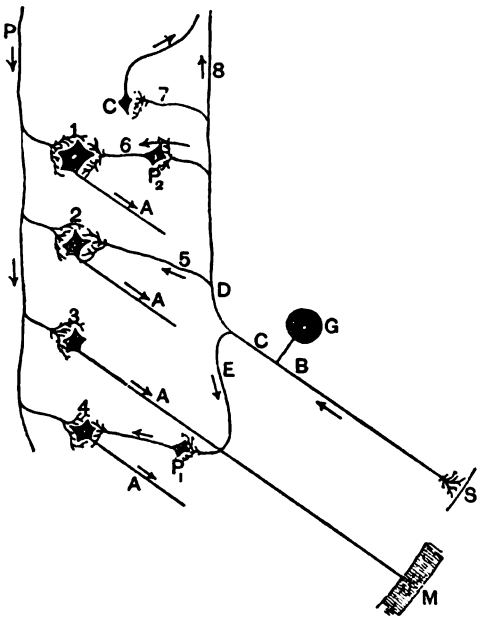

FIG. 535.—COURSE OF NERVE-FIBRES IN THE SPINAL CORD (FROM HALLIBURTON'S 'HANDBOOK OF PHYSIOLOGY' (AFTER SCHÄFER).

P. Pyramidal Tract
1, 2, 3, 4. Anterior Cornual Cells
A, A, A, A. Axons of Anterior Cornual Cells
M. Muscular Fibre
G. Unipolar Cell of a Spinal Ganglion, giving Origin to a Fibre of a Posterior Nerve-Root
B. Peripheral Branch of Fibre
S. Skin
C (lower C) Central Branch of Fibre, passing into the Spinal Cord
E. Descending Branch of Fibre in the Spinal Cord
D. Ascending Branch of Fibre in the Spinal Cord
P1, P2. Posterior Cornual Cells
C (upper C). Cell of Clarke's Column
5. Collateral, passing directly to arborize around an Anterior Cornual Cell (2)
6. Collateral, with an Intermediate Cell-Station in a Posterior Cornual Cell (P_2)
7. Collateral, arborizing around a Cell of Clarke's Column (upper C)
8. Continuation of Main Ascending Branch of Fibre

as intermediate cell-stations. (2) Others terminate in arborizations around the cells of Clarke's column in the thoracic region, and from these cells, as intermediate cell-stations, new axons pass into the direct cerebellar tract. (3) A few extend as high as the medulla oblongata, lying at first in Burdach's column, but being subsequently displaced into the column of Goll.

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Spino-thalamic Fibres.—Some of the axons of the cells in the posterior grey cornu, around which certain fibres of the posterior nerve-roots have terminated in aborizations, enter the anterior white commissure. Having crossed to the opposite side, they enter the lateral column, and ascend to the optic thalamus of the side to which they have crossed. These fibres are known as the spino-thalamic fibres.

Spinal Ganglia.—These are situated on the *posterior* roots of the spinal nerves in the intervertebral foramina, and outside the theca, though invested by a prolongation from it. Each ganglion is oval, and consists of unipolar nerve-cells. The single pole of each cell divides into two processes, one of which is *centripetal* and forms part of the posterior nerve-root, whilst the other is *centrifugal* and passes into the spinal nerve. The pole and its inward and outward processes resemble the letter T. In early life the cells are bipolar.

The fibres of the posterior nerve-roots have their deep origins in the unipolar cells of the spinal ganglia, and they *grow into* the spinal cord. On the other hand, the fibres of the anterior nerve-roots have their deep origins within the spinal cord, where they arise as the axons of the multipolar nerve-cells of the anterior cornu of grey matter, and they *grow outwards*.

Conducting Tracts in the Spinal Cord—Posterior Column.—The recognised tracts of this column are as follows: (1) the column of Goll; (2) the column of Burdach, which contains the 'comma' tract; (3) the tract of Lissauer, which also invades the lateral column posteriorly; and (4) the ventral tract.

The **column of Goll** lies close to the posterior median fissure. The **column of Burdach** is placed externally, next the posterior grey cornu. These two columns are separated from each other, above the level of the mid-thoracic region, by the *posterior intermediate septum* of pia mater. They are long tracts, and derive their fibres from the posterior nerve-roots.

The **comma tract** is situated within the column of Burdach, in the thoracic region, and lies internal to the posterior grey cornu. The fibres of which it consists are probably the descending branches of the fibres of the posterior nerve-roots.

The **tract of Lissauer,** or *posterior marginal bundle,* is situated on the surface of the cord opposite the apex of the posterior grey cornu, and it invades the adjacent portions of the posterior and lateral columns. Its fibres are derived from the posterior nerve-roots, and they ascend to terminate in the substantia gelatinosa of Rolando.

The **ventral tract** is situated at the deep or ventral part of the posterior column, close to the corresponding half of the posterior grey commissure. It is probably composed of association or longitudinal commissural fibres.

Lateral Column.—The tracts of this column are (1) the direct cerebellar tract, (2) the tract of Gowers, (3) the crossed or lateral pyramidal tract, (4) the lateral ground-bundle, and (5) the lateral limiting area.

The **direct cerebellar tract** (*dorso-lateral ascending cerebellar tract*)

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is an *ascending tract.* It consists of large fibres which are derived from the cells of the posterior vesicular column of Clarke in the mesial portion of the cervix of the posterior grey cornu. It commences in the lower part of the thoracic region, and, gradually increasing in size as it ascends, it passes through the lower part of the medulla oblongata, and finally is conducted to the cerebellum by the restiform body. It is situated in the posterior

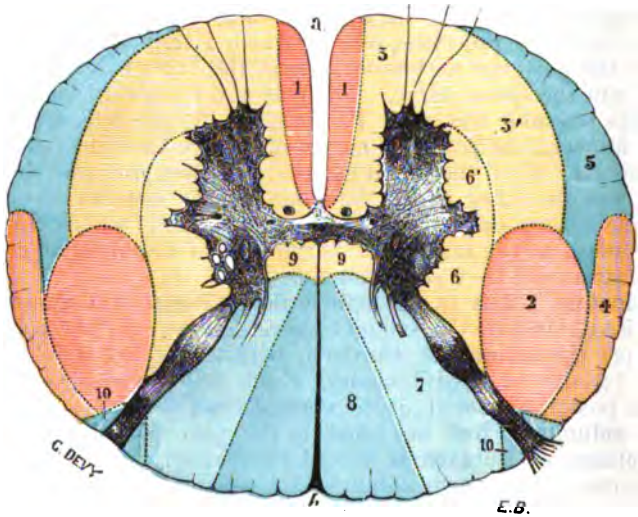

FIG. 536.—THE TRACTS OF THE SPINAL CORD (L. TESTUT'S 'ANATOMIE HUMAINE').

a. Anterior Median Fissure
b. Posterior Median Fissure
1. Direct Pyramidal Tract
2. Crossed Pyramidal Tract
3. Anterior Ground Bundle
3'. Lateral Ground Bundle
4. Direct Cerebellar Tract
5. Tract of Gowers
6, 6'. Lateral Limiting Zone
7. Tract of Burdach
8. Tract of Goll
9. Ventral Tract of Posterior Column
10. Tract of Lissauer

part of the lateral column, in front of the postero-lateral sulcus, where it lies on the surface of the cord, superficial to the crossed pyramidal tract.

The **tract of Gowers** (*antero-lateral ascending tract*, or *indirect cerebellar tract*) is situated in front of the direct cerebellar and crossed pyramidal tracts. It is broad behind, where it is in contact with the direct cerebellar tract and the crossed pyramidal tract, but anteriorly it tapers in the region of the emerging fasciculi of the anterior nerve-roots. The fibres of this tract are regarded as having their origin in the cells of the posterior grey cornu. It commences in the lower part of the thoracic region, and it can be traced through the medulla oblongata and pons Varolii into the

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cerebellum through the superior cerebellar peduncle: hence the name of indirect cerebellar tract.

The **crossed** or **lateral pyramidal tract** is a *descending tract.* It is situated in the posterior part of the lateral column, immediately in front of the posterior grey cornu, being separated from the surface of the cord by the direct cerebellar tract, and having the tract of Gowers and the lateral ground-bundle in front of it. Superiorly it can be traced across the middle line into the opposite pyramid of the medulla oblongata, and thence through the pons Varolii, crus cerebri, and internal capsule of the corpus striatum to the pyramidal cells of the Rolandic region of the cerebral cortex. Inferiorly it can be traced to the lower end of the cord. As the tract descends fibres leave it at regular intervals and enter the anterior grey cornu, where they terminate in arborizations around the anterior or motor cells, from which the fibres of the anterior or motor nerve-roots arise.

The crossed pyramidal tract is the chief path by which *motor* impulses are conveyed from the Rolandic region of the cerebral cortex to the various segments of the spinal cord.

The **lateral ground-bundle** is situated in front of the crossed pyramidal tract, having the tract of Gowers on its outer side, and the lateral limiting area on its inner side. Anteriorly it is continuous with the anterior ground-bundle. It consists of association or longitudinal commissural fibres.

The **lateral limiting area** is situated between the crescent of grey matter internally and the crossed pyramidal tract and lateral ground-bundle externally. It is intimately related to the latter bundle, and, like it, is probably composed of association or longitudinal commissural fibres.

Anterior Column.—The tracts of this column are (1) the direct or anterior pyramidal tract, and (2) the anterior ground-bundle.

The **direct** or **anterior pyramidal tract,** or **column of Türck,** is a *descending tract.* It represents the narrow *mesial* portion of the anterior column, and lies close to the anterior median fissure. As a rule it ceases about the mid-thoracic region, but it may be traceable as low as the lumbar enlargement, or it may cease about the centre of the cervical enlargement. Superiorly it is continued into the medulla oblongata, where it forms the *outer* portion of the pyramid of the same side. Thereafter its fibres are traceable through the pons Varolii, crus cerebri, and internal capsule of the corpus striatum to the pyramidal cells of the Rolandic region of the cerebral cortex of the same side. As the fibres of this tract descend in the cord they cross at intervals, in the anterior white commissure, to the opposite anterior column, and enter the anterior grey cornu. Here, like the fibres of the crossed pyramidal tract, they terminate in arborizations around the anterior or motor cells, from which the fibres of the anterior or motor nerve-roots arise.

It is to be noted that, whilst the fibres of the crossed pyramidal

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tract cross in the medulla oblongata, those of the direct pyramidal tract cross at intervals in the anterior white commissure of the spinal cord.

The **anterior ground-bundle** represents the greater part of the remainder of the anterior column. Like the lateral ground-bundle, with which it is continuous, it is composed, to a large extent, of fibres which act as association or longitudinal commissural fibres between segments of the cord at different levels.

In connection with the **antero-lateral column** there is a superficially-placed **antero-lateral descending cerebellar tract,** which is also known as the *anterior marginal bundle of Lowenthal.* It extends from the direct cerebellar tract to the direct pyramidal tract. Within the cord its nbres terminate in arborizations around the anterior or motor cells of the anterior grey cornu. Inferiorly it extends to the lumbar region of the cord. Superiorly its fibres become the axons of cells belonging to the nucleus of Deiters, and from these cells fibres proceed to the cortex of the cerebellum. These cells are to be regarded as intermediate cell-stations in the course of the fibres of the anterior marginal bundle of Lowenthal.

Summary of the White Matter of the Cord.—The white matter consists of nerve-fibres and neuroglia, and is arranged in three columns, anterior, lateral, and posterior, or, according to some authorities, two columns, antero-lateral and posterior. In the cervical and upper thoracic regions the posterior column is subdivided by the posterior intermediate furrow into the column of Goll, internal in position, and the column of Burdach, which is placed externally.

Tracts—Posterior Column.—(1) The column of Goll; (2) the column of Burdach (which contains the 'comma' tract); (3) the tract of Lissauer (posterior marginal bundle), which also invades the lateral column posteriorly; and (4) the ventral tract. **Lateral Column.**—(1) The direct cerebellar tract (dorso-lateral ascending cerebellar tract); (2) the tract of Gowers (antero-lateral ascending tract); (3) the crossed or lateral pyramidal tract; (4) the lateral ground-bundle; and (5) the lateral limiting area. **Anterior Column.**—(1) The direct or anterior pyramidal tract, or column of Türck; and (2) the anterior ground-bundle. **Antero-lateral Column.** — The anterior marginal bundle of Lowenthal (antero-lateral descending cerebellar tract).

The *descending tracts* are as follows: (1) the crossed or lateral pyramidal tract; (2) the direct or anterior pyramidal tract; (3) the 'comma' tract; and (4) the anterior marginal bundle of Lowenthal (antero-lateral descending cerebellar tract).

The *ascending tracts* are as follows: (1) the column of Goll; (2) the column of Burdach; (3) the direct cerebellar tract (dorso-lateral ascending cerebellar tract); (4) the antero-lateral ascending (cerebellar) tract of Gowers; and (5) the tract of Lissauer, or posterior marginal bundle.

The principal *longitudinal commissural fibres* are met with in (1) the anterior ground-bundle, (2) the lateral ground-bundle, (3) the lateral limiting area, and (4) the ventral tract.

Arteries of the Spinal Canal and Spinal Cord—Arteries of the Spinal Canal.—These vessels enter the spinal canal through the intervertebral and sacral foramina. In the cervical region they are branches of the vertebral and deep cervical arteries; in the thoracic and lumbar regions they are derived from the dorsal

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branches of the intercostal and lumbar arteries; and in the sacral region they come from the lateral sacral arteries. Within the spinal canal each **spinal artery** divides into three branches, namely, neural or central, and two parietal, anterior and posterior. The ***neural*** or ***central branch*** pierces the theca of the spinal cord. It supplies the coverings of the cord and the nerve-roots, and it anastomoses with the anterior and posterior spinal arteries on the cord. The neural branch is sometimes spoken of as the *lateral spinal artery*. The *anterior parietal branch* of each side passes to the back of the body of a vertebra, near the pedicle, and there it divides into two branches, ascending and descending. These anastomose with the adjacent offsets of the contiguous anterior parietal branches, and in this manner a **lateral longitudinal anastomotic chain** is formed, which communicates, at frequent intervals, with its fellow of the opposite side by transverse branches. From these transverse branches ascending and descending offsets are given off, which anastomose with adjacent offsets of contiguous transverse branches, and in this manner a **median longitudinal anastomotic chain** is formed on the backs of the bodies of the vertebræ. There are thus three longitudinal chains on the posterior surfaces of the bodies of the vertebræ, one being median and two lateral. From these chains branches are furnished to the bodies of the vertebræ and their ligaments. The *posterior parietal branch* of each side passes to the front of a lamina, where it acts in a manner similar to the anterior parietal branch. Two **posterior longitudinal anastomotic chains** are thus constructed in front of the laminæ, one at either side, which communicate at frequent intervals by transverse branches, and from these sources offsets are furnished to the laminæ and ligamenta subflava.

Arteries of the Spinal Cord.—These are: (1) the anterior spinal artery; (2) the posterior spinal arteries, right and left; and (3) the lateral spinal arteries, right and left (neural or central branches just described in connection with the spinal canal).

The **anterior spinal artery** is formed by the union of the *anterior spinal branches*, right and left, of the vertebral arteries. It descends along the front of the cord in the median line, and is reinforced at regular intervals by the lateral spinal arteries. In this manner an anterior longitudinal anastomotic chain is formed, which descends for some distance on the filum terminale.

The **posterior spinal arteries** are two in number, right and left, and each is a branch of the corresponding vertebral artery. Each vessel descends on the side of the cord in two branches, one being in front of, and the other behind, the posterior nerve-roots. These are reinforced by branches from the lateral spinal arteries, and the lateral longitudinal anastomotic chains, formed in this manner, extend over the entire length of the cord. There are thus five longitudinal anastomotic arterial chains in connection with the cord, namely, one anterior, and two lateral on each side, of which one is in front of, and the other behind, the posterior nerve-roots.

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From these chains branches are freely given to the pia mater, and through it to the cord.

Veins of the Spinal Column and Spinal Cord — Veins of the Spinal Column.—These veins, which form plexuses, are disposed in five sets, namely, (1) dorsal, (2) veins of the vertebral bodies, (3) anterior intraspinal, (4) posterior intraspinal, and (5) anterior extraspinal.

The **dorsal spinous venous plexus** is situated deeply upon the superficial surface of the neural arches of the vertebræ, under cover of the multifidus spinæ muscle. It receives its tributaries from the integument and muscles of the back, and it communicates with the posterior longitudinal intraspinal plexus by branches which pierce the ligamenta subflava. In the neck the blood is conveyed away from the plexus by veins which open into the vertebral venous plexus around the vertebral artery of each side; in the thoracic region by veins which join the dorsal branches of the intercostal veins; and in the lumbar region by veins which join the dorsal branches of the lumbar veins.

The **veins of the bodies of the vertebræ** (*venæ basis vertebræ*) are contained within the cancellated tissue of the vertebral bodies. They communicate in front with the anterior extraspinal veins, and posteriorly they terminate in two venous trunks which, emerging through the two foramina on the posterior surface of each vertebral body, open into the transverse communicating branch between the two anterior longitudinal intraspinal veins.

The **anterior longitudinal intraspinal veins** form two anastomotic chains, which are situated on the posterior surfaces of the bodies of the vertebræ, one on either side. They communicate with each other opposite the centre of each body by transverse branches which receive the terminal trunks of the venæ basis vertebræ. These transverse branches pass between the posterior common ligament and the bodies of the vertebræ. Superiorly the anterior intraspinal veins communicate with the vertebral and the transverse or basilar plexuses of veins, and laterally an offset passes outwards through each intervertebral foramen, which, with that of the posterior intraspinal vein, forms a plexus around the adjacent spinal nerve.

The **posterior longitudinal intraspinal veins** are situated in front of the laminæ, one on either side, and they are connected at frequent intervals by transverse branches. They communicate with the dorsal spinous venous plexus by branches which pierce the ligamenta subflava. Superiorly they communicate with the marginal sinuses, on either side of the foramen magnum and vermiform fossa, which by their union form the occipital sinus. With the marginal sinuses and the anterior intraspinal veins they form a venous ring at the foramen magnum. Laterally each vein sends outwards through the corresponding intervertebral foramen an offset, which, with that of the anterior intraspinal vein, forms a plexus around the adjacent spinal nerve.

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The anterior and posterior intraspinal veins are situated between the theca of dura mater and the wall of the spinal canal.

The **anterior extraspinal veins** form a plexus along the anterior aspect of the bodies of the vertebræ, which is most copious in the neck. On either side it communicates with the vertebral plexus, around the vertebral artery in the neck, the intercostal veins in the thoracic region, and the lumbar veins in the lumbar region. It is also connected with the venæ basis vertebræ.

Veins of the Spinal Cord.—These vessels lie within the substance of the pia mater, and are disposed as venous chains, one being in front, one behind, and two on either side. The anterior vessel lies over the anterior median fissure beneath the anterior spinal artery;

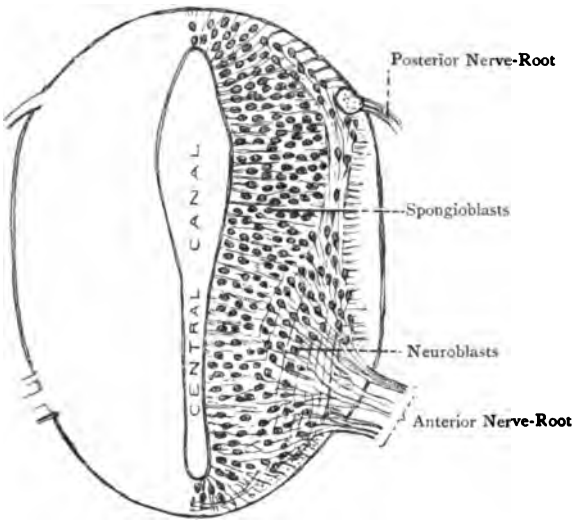

FIG. 537.—SECTION OF THE SPINAL CORD OF A HUMAN EMBRYO OF FOUR WEEKS (HIS).

the posterior vessel is also mesially placed; and the two lateral vessels are situated one in front of, and the other behind, the posterior nerve-roots. Besides these principal chains the veins form a plexus on the surface of the cord. Laterally branches emerge through the intervertebral foramina, which, along with the offsets of the anterior and posterior intraspinal veins, form plexuses around the spinal nerves. From these plexuses the blood is conveyed on either side into the vertebral plexus and deep cervical vein in the neck, and into the intercostal and lumbar veins in the corresponding regions.

Lymphatics.—There are no lymphatic vessels in the spinal cord. Their place is taken by spaces in the outer coat of the arteries,

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called **perivascular spaces,** which are in communication with the subarachnoid space.

Development of the Spinal Cord.—The spinal cord is developed from the spinal portion of the neural tube of epiblast. The epiblast of the neural tube is composed of closely-set, columnar epithelial cells, called **spongioblasts,** the inner free ends of which line the tube, and are ultimately provided with cilia. These cells constitute at first the entire wall of the neural tube. As the wall increases in thickness they become elongated, and ramifications are formed between adjacent cells, thus giving rise to a reticulum, called the *myelospongium.*

Other cells, round in outline, called **germinal cells,** soon make their appearance between the inner or free ends of the spongioblasts.

Between the layer of germinal cells and the periphery of the spinal cord a third group of cells appears, these cells being called **neuroblasts.** The outer ends of these cells are prolonged into processes which are primitive fibres of the anterior roots of the spinal nerves.

The wall of the spinal portion of the neural tube thus comes to be formed of three sets of cells, namely, spongioblasts, germinal cells, and neuroblasts.

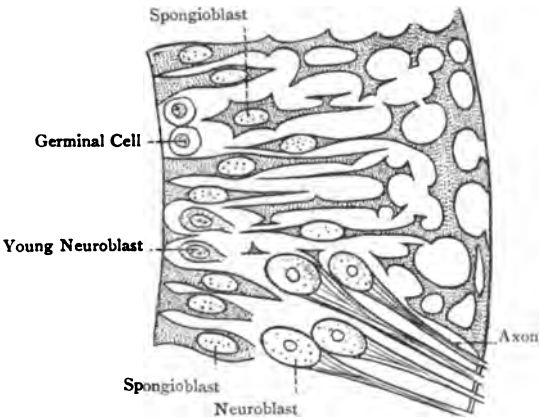

FIG. 538.—THE CELLS OF THE SPINAL CORD OF THE HUMAN EMBRYO (L. TESTUT'S 'ANATOMIE HUMAINE'; AFTER HIS).

The neuroblasts represent the central portion or grey matter of the primitive cord. The external portion or periphery is composed of the outer ends of the spongioblasts, a portion of the myeloplasm, and the processes (primitive nerve-fibres) which are prolonged from the outer ends of the neuroblasts, and these represent the white matter of the primitive cord. Subsequently longitudinal nerve-fibres make their appearance, and give rise to the white columns of the cord.

The cornua of grey matter are developed from the central collections of neuroblasts. As the anterior grey cornua grow outwards, and as the anterior columns of white matter become enlarged, the anterior median fissure makes its appearance.

The neuroglia of the cord and the lining epithelium of the central canal are developed from the spongioblasts, and are therefore of epiblastic origin.

The central canal of the cord is the persistent remains of the lumen of the neural tube.

The membranes of the cord are of mesoblastic origin.

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THE ENCEPHALON.

The encephalon is the part of the cerebro-spinal axis which is contained within the cranial cavity. It is composed of the medulla oblongata, pons Varolii, cerebellum, and cerebrum. Originally it consists of three hollow vesicles, namely, the anterior cerebral vesicle, which represents the prosencephalon or fore-brain; the middle cerebral vesicle, representing the mesencephalon or mid-brain; and the posterior cerebral vesicle, corresponding to the rhombencephalon or hind-brain.

Encephalon = { **Prosencephalon** or Fore-brain. / **Mesencephalon** or Mid-brain. / **Rhombencephalon** or Hind-brain.

The subdivisions of the prosencephalon are the telencephalon and the thalamencephalon or diencephalon; the mesencephalon remains undivided; and the subdivisions of the rhombencephalon are the metencephalon and the myelencephalon.

Prosencephalon = { **Telencephalon.** / **Thalamencephalon** or **Diencephalon.**

Mesencephalon = **Mesencephalon.**

Rhombencephalon = { **Metencephalon.** / **Myelencephalon.**

The various parts of the encephalon which are developed from these subdivisions will be made evident from the following table:

Telencephalon = { Cerebral Hemispheres. / Lateral Ventricles. / Anterior part of Third Ventricle. / Foramina of Monro. / Olfactory Lobes.

Thalamencephalon or **Diencephalon** = { Posterior Part of Third Ventricle. / Optic Thalami. / Pineal Body. / Interpeduncular Structures. / Pituitary Body. / Optic Nerve and Retina.

Mesencephalon = { Corpora Quadrigemina. / Crura cerebri. / Aqueduct of Sylvius.

Metencephalon = { Cerebellum. / Pons Varolii. / Pontine Part of the Fourth Ventricle.

Myelencephalon = { Medulla Oblongata or Bulb. / Bulbar Part of Fourth Ventricle.

General Description of the Base and Superior Surface of the Encephalon.

The inferior aspect of the encephalon is known as the **base.** In the following general description of the parts which it presents the order pursued is, as nearly as possible, from behind forwards and upwards.

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The **medulla oblongata,** or **bulb,** lies on the under aspect of the cerebellum, in the median line, occupying the vallecula which separates the two cerebellar hemispheres. The surface exposed is the ventral surface, which presents (1) the anterior median fissure, crossed at its lower part by the decussation of the pyramids; (2) the pyramid, on either side of this fissure; and (3) the olivary body, external to each pyramid.

The **hemispheres of the cerebellum** lie one on either side of the medulla oblongata, and they conceal from view the posterior parts of the cerebral hemispheres, and the posterior part of the great longitudinal fissure. They are characterized by the laminated arrangement of their nervous matter, the laminæ being curved and separated from each other by fissures. Posteriorly the hemispheres are separated from each other by the posterior notch. When the medulla oblongata is raised, and the cerebellar hemispheres slightly separated from each other, the **vallecula** is fully exposed, and the **inferior vermis** is seen lying deeply in it, with the *sulcus vallecul*æ on either side of it.

The **pons Varolii** forms a prominent elevation above the medulla oblongata, the surface exposed being the ventral surface. In the median line this surface presents a longitudinal groove, which is occupied by the basilar artery. On either side of the pons the **middle peduncle of the cerebellum** is seen, passing outwards and backwards into the cerebellar hemisphere.

The **temporal lobes of the cerebrum** are situated in front of the cerebellar hemispheres, and are conspicuous by their prominence. Each terminates anteriorly in a projecting extremity, called the **temporal pole.**

The **stem** of the **fissure of Sylvius** lies immediately in front of the temporal lobe, and is occupied by the middle cerebral artery. At the inner end of the stem of the fissure of Sylvius is the depression known as the *vallecula Sylvii.*

The **frontal lobe of the cerebrum** lies in front of the stem of the fissure of Sylvius. The exposed part is the orbital surface, which is separated from its fellow of the opposite side by the great longitudinal fissure. Each orbital surface presents a straight fissure, called the **olfactory sulcus,** which is situated near the great longitudinal fissure, and is parallel to it. This sulcus is occupied by the **olfactory tract** and **olfactory bulb.**

The **crura cerebri,** right and left, appear at the upper border of the pons Varolii, and soon diverge from each other as they pass forwards and upwards to sink into the cerebral hemispheres.

The **optic tract** of each side winds round the outer and ventral aspects of the corresponding crus cerebri. Its course is forwards and inwards towards its fellow of the opposite side.

The **optic commissure,** or **chiasma,** connects the two optic tracts after their convergence.

The **optic nerves,** right and left, leave the front of the commissure, and pass forwards and outwards to the optic foramina.

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The **interpeduncular space** is situated in front of, and above, the pons Varolii. It is somewhat diamond-shaped, and its boundaries are as follows : posteriorly, the upper border of the pons ; anteriorly, the optic commissure ; and, laterally, the crus cerebri and optic tract, in this order from behind forwards. The following parts lie within this space, in the order named, from behind forwards :

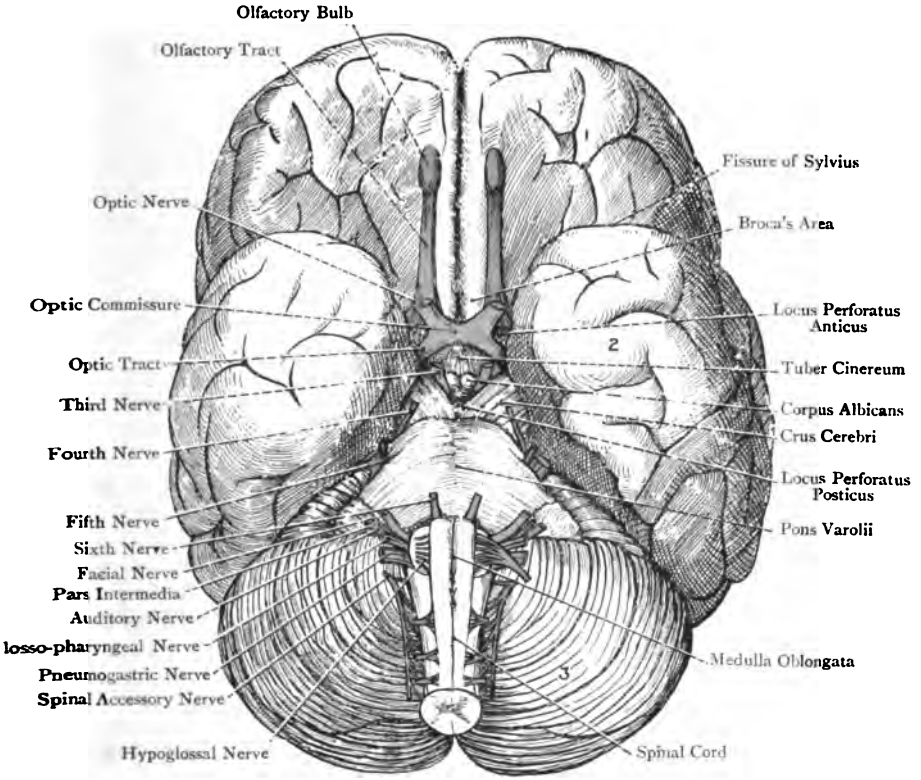

FIG. 539.—THE BASE OF THE ENCEPHALON, AND THE CRANIAL NERVES.

1, Frontal Lobe (Orbital Surface) ; 2, Temporal Lobe ; 3, Cerebellum.

(1) the locus perforatus posticus ; (2) the corpora albicantia or mammillaria ; and (3) the tuber cinereum, with the infundibulum. (The region which is directly above the interpeduncular space constitutes the third ventricle.)

The **locus perforatus posticus** corresponds to the posterior median angle of the diamond-shaped interpeduncular space, and it lies in a deep depression, called the **interpeduncular fossa,** or *fossa Tarini.*

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The grey matter which forms it is perforated by openings for the passage of the postero-mesial branches of the posterior cerebral arteries.

The **corpora albicantia** or **mammillaria** are situated directly in front of the locus perforatus posticus, and present the appearance of small, white, pea-like bodies, lying close to the median line.

The **tuber cinereum** extends from the corpora albicantia to the optic commissure, and is composed of grey matter. The **infundibulum** is connected with the tuber cinereum close behind the optic commissure, and passes downwards to the posterior part of the pituitary body.

The **locus perforatus anticus** of each side coincides with the vallecula Sylvii at the inner end of the stem of the fissure of Sylvius. It lies outside the interpeduncular space, close to the outer aspect of the optic commissure. It consists of grey matter, which is perforated by openings for the passage of a few antero-mesial branches of the anterior cerebral artery, and numerous antero-lateral branches of the middle cerebral artery. These branches are destined for the nucleus caudatus and nucleus lenticularis of the corpus striatum, the grey matter of which nuclei comes to the surface of the brain at the locus perforatus anticus.

The medulla oblongata and pons Varolii occupy the basilar groove of the interior of the base of the skull; the cerebellar hemispheres occupy the cerebellar fossæ of the occipital bone; the temporal lobes of the cerebrum sink deeply into the lateral divisions of the middle fossa of the base of the skull; the orbital surfaces of the frontal lobes occupy the lateral divisions of the anterior fossa; the stem of the fissure of Sylvius faces the posterior or Sylvian border of the small wing of the sphenoid; the optic commissure rests upon the olivary eminence and optic groove of the sphenoid; and the olfactory bulb rests upon one half of the cribriform plate of the ethmoid bone.

Superficial or Surface Origins of the Cranial Nerves.

The **first** or **olfactory nerve** occupies the following positions: The **olfactory bulb** and **olfactory tract** occupy the olfactory sulcus on the orbital surface of the frontal lobe, near the great longitudinal fissure; and the olfactory filaments pass through the foramina of the cribriform plate of the ethmoid bone on their way from the olfactory cells of the olfactory mucous membrane to the olfactory bulb. Posteriorly the olfactory tract divides into two roots, mesial and lateral. The *mesial root* curves inwards behind the area of Broca to the callosal gyrus. The *lateral root* passes backwards and outwards across the outer part of the locus perforatus anticus. The triangular area of grey matter, which is situated between the diverging roots of the olfactory tract, is called the *trigonum olfactorium*. It is sometimes spoken of as the *middle* or *grey root* of the olfactory tract. The **area of Broca** is situated in front of the mesial

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(inner) root of the olfactory tract, and is continuous with the callosal gyrus.

The **optic tract** curves round the crus cerebri from without inwards. The two optic tracts, having converged, are connected by the **optic commissure,** which lies at the anterior part of the interpeduncular space. The **optic nerve** is connected with the lateral extremity of the front part of the optic commissure.

The **third** or **oculo-motor nerve** emerges through the oculo-motor sulcus on the inner aspect of the crus cerebri, just above or in front of the pons Varolii, and close to the locus perforatus posticus.

The **fourth, pathetic,** or **trochlear nerve,** having emerged from the upper part of the superior medullary velum, or valve of Vieussens, makes its appearance in the interval between the crus cerebri internally and the temporal lobe externally.

The **fifth, trigeminal,** or **trifacial nerve** consists of two roots, which emerge, close together, from the lateral aspect of the ventral surface of the pons Varolii. The sensory root is large, and the motor root, which is small, lies above and slightly internal to the sensory root.

The **sixth** or **abducent nerve** emerges at the lower border of the pons Varolii, just external to the pyramid of the medulla oblongata.

The **seventh** or **facial nerve** (*portio dura*) emerges at the lower border of the pons, in front of the restiform body of the medulla oblongata.

The **eighth** or **auditory nerve** (*portio mollis*) likewise emerges at the lower border of the pons, in front of the restiform body of the medulla oblongata. It lies on the outer side of the facial nerve.

The **pars intermedia of Wrisberg** is a small nerve which appears between the facial and auditory nerves.

The **ninth** or **glosso-pharyngeal nerve** emerges, in the form of about six fasciculi, from the postero-lateral sulcus of the medulla oblongata, between the olivary body and the restiform body, immediately below the facial nerve.

The **tenth** or **pneumogastric nerve** lies directly below the glossopharyngeal nerve, and emerges by several fasciculi from the postero-lateral sulcus of the medulla oblongata in front of the restiform body.

The **eleventh** or **spinal accessory nerve** has several roots which lie below the fasciculi of the pneumogastric nerve. These emerge from the medulla oblongata and the upper part of the lateral column of the spinal cord as low as the level of the fifth cervical nerve, and they lie below the fasciculi of the pneumogastric nerve, and external to, or in front of, the posterior roots of the adjacent cervical spinal nerves.

The **twelfth** or **hypoglossal nerve** emerges by several fasciculi through the antero-lateral sulcus of the medulla oblongata, between the pyramid and the olivary body. These fasciculi lie in line with the sixth nerve superiorly.

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Arteries at the Base of the Encephalon.—The arteries which supply the brain are the two vertebral and the two internal carotid arteries.

The **vertebral arteries** incline inwards as they ascend on the ventral aspect of the medulla oblongata, and at the lower border of the pons Varolii they unite to form the basilar artery. The branches of each vertebral artery to be noted are as follows: (1) the *posterior spinal branch*, which arises from the main vessel immediately after it has pierced the dura mater, and descends upon the side of the medulla oblongata to the spinal cord; (2) the *anterior spinal branch*, which arises higher up than the preceding, and passes downwards and inwards on the ventral aspect of the medulla oblongata to unite with its fellow and form the *anterior spinal artery*; and (3) the *posterior inferior cerebellar branch*, of large size, which arises from the main vessel near the pons, and passes backwards round the medulla oblongata to enter the vallecula of the cerebellum.

The **basilar artery** extends from the lower border of the pons Varolii to the upper border, occupying the basilar groove on its ventral surface. It is formed by the union of the two vertebral arteries, and terminates by dividing into the two posterior cerebral arteries. The branches of the basilar artery to be noted on either side are as follows: (1) the *transverse arteries of the pons*; (2) the *internal auditory artery*, which accompanies the auditory nerve through the meatus auditorius internus; (3) the *anterior inferior cerebellar artery*, which arises from the basilar about its centre, and passes backwards to the inferior surface of the cerebellar hemisphere; (4) the *superior cerebellar artery*, which arises from the basilar near its termination, and passes outwards close to the upper border of the pons, and then round the outer side of the crus cerebri to the superior surface of the cerebellar hemisphere; and (5) the *posterior cerebral artery*, which arises from the termination of the basilar, and passes outwards, parallel to the superior cerebellar artery, and then round the outer side of the crus cerebri to the inferior surface of the occipital lobe. The posterior cerebral and superior cerebellar arteries are separated from each other by the third and fourth cranial nerves, the latter being the external of the two. The branches of the posterior cerebral artery to be noted, amongst others, are as follows: (1) *postero-mesial*, which pass to the locus perforatus posticus; (2) *postero-lateral*, which pass round the outer side of the crus cerebri; and (3) *posterior choroidal*, which pass to the upper part of the choroidal fissure.

The **internal carotid artery** of each side appears at the vallecula Sylvii, and there divides into the anterior and middle cerebral arteries. Near its termination it gives off the **posterior communicating artery,** which passes backwards to join the posterior cerebral artery. It also gives off the **anterior choroidal artery,** which passes backwards and outwards between the crus cerebri and the uncinate gyrus to the lower and anterior part of the choroidal fissure.

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The **anterior cerebral artery** passes forwards and inwards, and enters the great longitudinal fissure. As it is about to enter that fissure it is connected with its fellow of the opposite side by the **anterior communicating artery,** which is short, but of fairly large size. Amongst other branches the following are to be noted arising from the anterior cerebral artery : (1) *antero-mesial,* few and inconstant, and (2) *antero-lateral,* both of which pass to the locus perforatus anticus.

The **middle cerebral artery,** of large size, sinks into the fissure of Sylvius, which it traverses in an outward direction. Before disappearing into the fissure *antero-lateral ganglionic branches* are to be

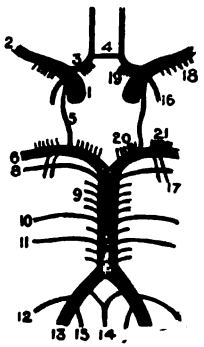

FIG. 540.—THE ARTERIES AT THE BASE OF THE BRAIN, AND THE CIRCLE OF WILLIS.

1. Internal Carotid
2. Middle Cerebral
3. Anterior Cerebral
4. Anterior Communicating
5. Posterior Communicating
6. Posterior Cerebral
7. Basilar
8. Superior Cerebellar
9. Transverse Pontine
10. Internal Auditory
11. Anterior Inferior Cerebellar
12. Posterior Inferior Cerebellar
13. Vertebral
14. Anterior Spinal
15. Posterior Spinal
16. Anterior Choroid
17. Posterior Choroid
18. Central or Ganglionic
19. Central or Ganglionic
20. Central or Ganglionic (Postero-mesial)
21. Central or Ganglionic (Postero-lateral)

noted arising from it, which are arranged in two sets, *internal striate* and *external striate,* which are destined chiefly for the component parts of the corpus striatum.

Circle of Willis.—This is an important communication between the vertebral and internal carotid arterial systems at the base of the brain, which is situated around the interpeduncular space. It is not actually a circle, though so named, but is a heptagon—that is to say, it has seven angles and seven sides.

Commencing at the median line posteriorly, and proceeding forwards on either side to the median line in front, at the great longitudinal fissure, the component arteries of the circle are as follows : (1) the basilar, (2) the posterior cerebral, (3) the posterior communicating, (4) the internal carotid, (5) the anterior cerebral, and (6) the anterior communicating. The connection between the

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two posterior cerebral arteries is effected by means of the basilar artery; the connection between the posterior cerebral and internal carotid arteries is effected by means of the posterior communicating artery; and the connection between the two anterior cerebral arteries is effected by means of the anterior communicating artery. These communications serve to insure a regular supply of arterial blood to the brain in cases of obstruction to one or other of the

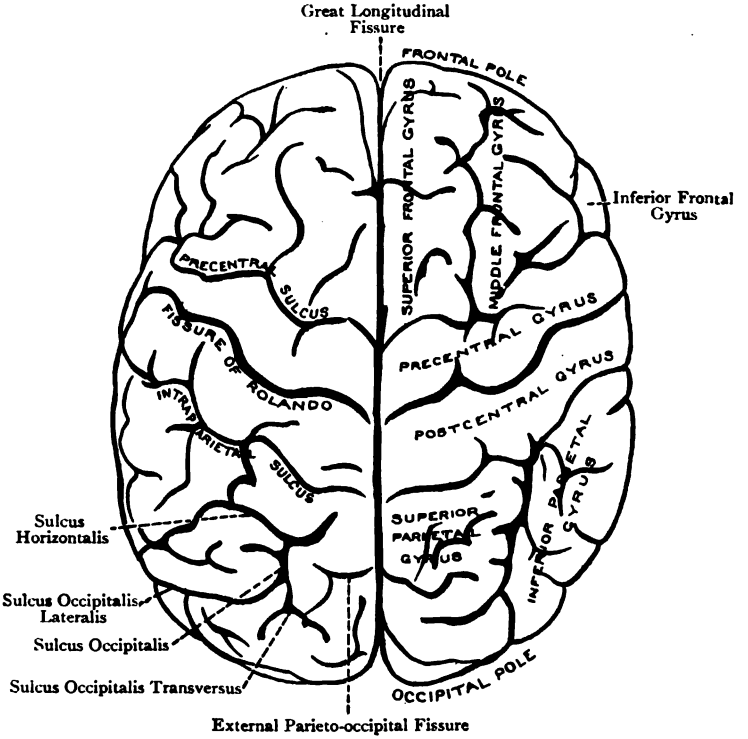

FIG. 541.—THE CEREBRAL HEMISPHERES (SUPERIOR VIEW).

principal arterial trunks. The communications also serve to equalize the circulation of blood through the different parts of the brain.

Superior Surface of the Brain.—The brain is ovoid superiorly, its greatest breadth corresponding to the positions of the parietal eminences of the parietal bones. In the median line it presents a deep cleft, called the **great longitudinal fissure,** which extends from the front to the back, and divides it into two **hemispheres,** right and left. This fissure is occupied by a process of the dura mater, called the **falx cerebri,** and the corpus callosum lies at its deep part. In front of the corpus callosum the fissure extends down to, and is

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visible on, the base of the brain, but behind the corpus callosum it only extends to the level of the tentorium cerebelli, which separates the cerebellum from the posterior parts of the cerebral hemispheres. The fissure, therefore, in this situation is not visible inferiorly until the cerebellum and the tentorium cerebelli have been removed.

Each **hemisphere** is semi-ovoid, its mesial or inner surface being flat. The anterior and posterior extremities are rounded, the former being the thicker of the two. The anterior extremity is known as the **frontal pole,** and the posterior extremity forms the **occipital pole.** The surface of each hemisphere consists of grey matter, which is spoken of as the **cerebral cortex.** Superiorly and externally it is convex in adaptation to the concavity of the vault of the cranium. It is broken up into a number of tortuous eminences, called **gyri** or **convolutions,** and these are separated from each other by clefts, called **sulci** or **fissures.** The surfaces of the gyri which bound the sulci are covered with grey matter, like their exterior. The pia mater closely covers the gyri, and also dips into the sulci, so as to cover the opposed surfaces of the gyri. The arachnoid membrane, however, does not dip into the sulci, but passes over them. The sulci are of various depths, but the average depth may be said to be $\frac{1}{2}$ inch.

RHOMBENCEPHALON.

1. The Medulla Oblongata.

The **medulla oblongata** or **bulb** (*myelencephalon*) is the continuation upwards of the spinal cord, and it extends from the lower margin of the foramen magnum to the lower border of the pons Varolii. Its direction is upwards and slightly forwards, and it measures 1 inch in length, $\frac{3}{4}$ inch in breadth at the widest part, and rather more than $\frac{1}{2}$ inch in thickness. Inferiorly its girth corresponds with that of the spinal cord, but it widens superiorly, so that its shape is somewhat pyramidal. Its anterior or ventral surface lies in the basilar groove of the occipital bone, and its posterior or dorsal surface is directed towards the vallecula of the cerebellum. It is composed of two symmetrical halves, its bilateral symmetry being indicated superficially by upward prolongations of the anterior and posterior median fissures of the spinal cord. The *anterior median fissure* extends as high as the lower border of the pons Varolii, where it expands slightly and ends in a blind recess, called the *foramen cæcum.* The lower part of the fissure is crossed by several bundles of fibres which are derived from the inner three-fourths of each pyramid, and the decussation thus formed is known as the **decussation of the pyramids.** The *posterior median fissure* only extends over the lower half of the medulla, and it terminates at the level of the calamus scriptorius.

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The lower half of the medulla contains a prolongation of the central canal of the cord, which opens at the calamus scriptorius into the lower part of the fourth ventricle. This portion of the medulla is known as the *closed part*. In the upper half of the medulla the grey matter comes to the surface posteriorly over the lower portion of the floor of the fourth ventricle, and the upper half of the medulla is known as the *open part*.

In series with the anterior nerve-roots of the spinal cord the fasciculi of the hypoglossal nerve emerge from the medulla along a groove, called the *antero-lateral sulcus*, which is situated in front of the olivary body. These fasciculi, however, unlike those of the anterior nerve-roots of the cord, emerge in a straight line. In series

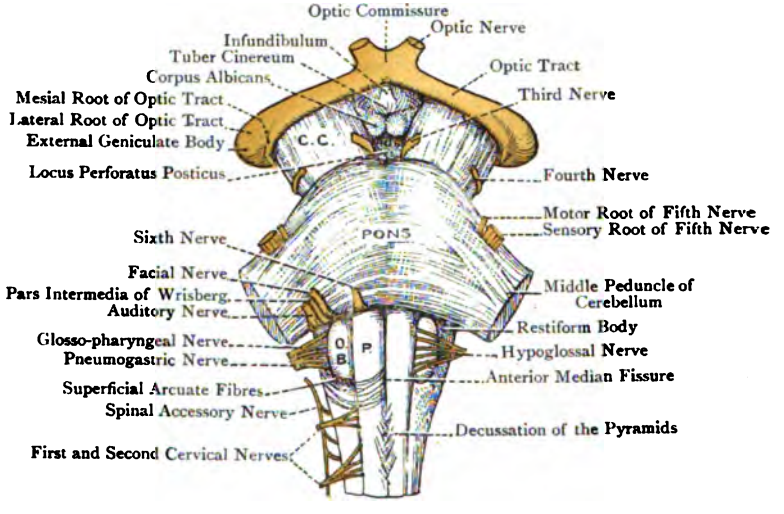

FIG. 542.—THE MEDULLA OBLONGATA, PONS VAROLII, AND INTERPEDUNCULAR REGION.

C.C., Crus Cerebri ; P., Pyramid ; O.B., Olivary Body.

with the posterior nerve-roots of the spinal cord the fasciculi of the spinal accessory, pneumogastric, and glosso-pharyngeal nerves appear. These numerous fasciculi are connected with the medulla along a groove, called the *postero-lateral sulcus*, which is continuous with the corresponding sulcus of the spinal cord, and is situated behind the olivary body. The antero-lateral and postero-lateral sulci, along with the nerve-fasciculi connected with them, divide the corresponding half of the medulla into three areæ—anterior, lateral, and posterior.

Anterior Area.—This area is situated between the anterior median fissure and the antero-lateral sulcus with the fasciculi of the hypoglossal nerve. It constitutes the **pyramid** of the medulla.

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As regards position, it is continuous with the anterior column of the spinal cord, and it is composed of bundles of longitudinal nerve-fibres. Inferiorly it is narrow, but superiorly it expands, and at the lower border of the pons it undergoes a slight constric-

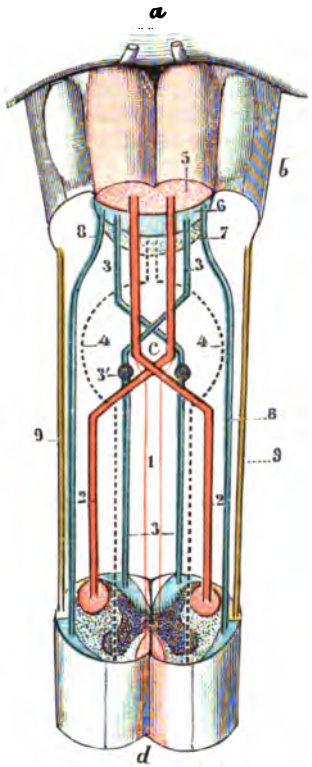

FIG. 543.—THE DECUSSATION OF THE PYRAMIDS. SCHEME REPRESENTING THE PASSAGE OF THE VARIOUS TRACTS FROM THE SPINAL CORD TO THE MEDULLA (L. TESTUT'S 'ANATOMIE HUMAINE').

a. Pons Varolii
b. Medulla Oblongata (anterior aspect)
c. Decussation of the Pyramids
d. Section of the Cervical Spinal Cord
1. Direct Pyramidal Tract
2. Crossed Pyramidal Tract
3. Sensory Tract
3'. Nucleus Gracilis et Nucleus Cuneatus
4. Antero-lateral Ground-Bundle
5. Anterior Pyramid
6. Fillet
7. Posterior Longitudinal Bundle
8. Tract of Gowers
9. Direct Cerebellar Tract

tion, after which it enters the pons. Its fasciculi now become separated, and, after traversing the pons, they are gathered up again at its upper border into the corresponding crus cerebri. The two pyramids, right and left, constitute the great **motor tracts** of the medulla. Each pyramid divides inferiorly into two

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parts, an external, which is small, and an internal, of large size. The fibres of the *external* portion are continued into the corresponding anterior column of the spinal cord, where they constitute the **direct pyramidal tract,** which lies close to the anterior median fissure. The fibres of the *internal* portion cross to the opposite side in the lower part of the anterior median fissure of the medulla, and then they sink into the posterior part of the lateral column of the spinal cord on the side to which they have crossed, where they constitute the **crossed pyramidal tract.** The intercrossing which takes place in the lower part of the anterior median fissure of the medulla is called the **decussation of the pyramids.** It usually involves three-fourths of the fibres of each pyramid. The only part of the anterior column of the spinal cord which is continued into the corresponding pyramid of the medulla is the direct pyramidal tract. The remainder of the anterior column of the cord, namely, the anterior ground-bundle, on entering the medulla, takes up a deep position behind and external to the pyramid.

The superficial surface of each pyramid is crossed, above the level of the decussation, by the *anterior superficial arcuate fibres*, which emerge from the anterior median fissure, and arch outwards and backwards to the restiform body. The sixth cranial nerve emerges at the lower border of the pons Varolii immediately external to the pyramid and in line with the fasciculi of the hypoglossal nerve.

Lateral Area of the Medulla.—This area is situated between the antero-lateral sulcus, with the fasciculi of the hypoglossal nerve, and the postero-lateral sulcus, with the fasciculi of the spinal accessory, pneumogastric, and glosso-pharyngeal nerves. Superficially it presents superiorly an oval swelling, called the **olivary body** or **eminence,** and inferiorly (*lateral tract*) it appears to be a prolongation of the lateral column of the spinal cord. This, however, is far from being the case. The crossed pyramidal tract of the lateral column of the cord sweeps obliquely across to form the larger and internal portion of the pyramid of the medulla on the opposite side ; and the direct cerebellar tract of the lateral column of the cord passes obliquely backwards into the restiform body of the medulla on the same side. The portions, therefore, of the lateral column of the cord which are prolonged into the lower part of the lateral area of the medulla (lateral tract) are : (1) the tract of Gowers, and (2) the lateral ground-bundle. These ascend to the lower part of the olivary body, where they are crossed by the anterior superficail arcuate fibres. The majority of their fibres then sink beneath the olivary body in their upward course, but a few of them ascend superficially close behind it on their way to the pons Varolii. The lateral area of the medulla below the olivary body therefore consists of the tract of Gowers and the lateral ground-bundle, both of which are prolonged from the lateral column of the cord of the same side.

Olivary Body or Eminence.—This, as stated, is an oval swelling, situated in the upper part of the lateral area of the medulla. Its

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long axis is placed vertically, and in this direction it measures about ½ inch. Superiorly it comes very nearly into contact with the pons Varolii, from which it is separated by a deep transverse groove; and inferiorly the anterior superficial arcuate fibres arch over it. The fasciculi of the hypoglossal nerve are on its mesial side, and posteriorly those of the spinal accessory, pneumogastric, and glosso-pharyngeal nerves appear, with the intervention of some ascending fibres derived from the lateral column of the spinal cord. The seventh or facial and eighth or auditory nerves make their appearance at the lower border of the pons, external to the upper end of the olivary body, the facial nerve being the *internal* of the

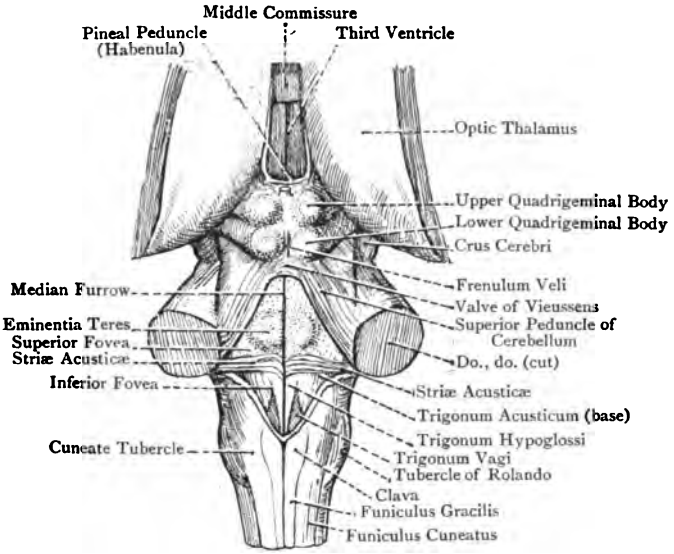

FIG. 544.—THE FLOOR OF THE FOURTH VENTRICLE AND ADJACENT PARTS

two, and the pars intermedia of Wrisberg lies between it and the auditory nerve.

Posterior Area of the Medulla.—This area is situated behind the postero-lateral sulcus, with the fasciculi of the spinal accessory, pneumogastric, and glosso-pharyngeal nerves. Posteriorly it extends to the posterior median fissure of the lower or closed part of the medulla, and to the lateral boundary of the lower portion of the fourth ventricle in the upper or open part of the medulla. Like the lateral area, it is divided into two portions, upper and lower. The *lower portion* is in direct continuity with the posterior column of the spinal cord, and it presents upward prolongations of the columns of Goll and of Burdach. The prolongation of Goll's column is known in the medulla as the **funiculus gracilis,** and that

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of Burdach's column as the **funiculus cuneatus,** these two funiculi being separated by an upward continuation of the posterior intermediate furrow of the cord. The funiculus gracilis is the internal of the two funiculi. When the funiculi reach the level of the calamus scriptorius each becomes enlarged. The enlargement formed by the funiculus gracilis is called the **clava,** and that formed by the funiculus cuneatus is called the **cuneate tubercle.** As the medulla opens out at the calamus scriptorius to form the lower part of the floor of the fourth ventricle the clavæ diverge, and the central canal of the spinal cord appears in the angle between them. Beneath the funiculus gracilis and funiculus cuneatus, as well as beneath the clava and cuneate tubercle, there is in each case an elongated nucleus of grey matter. These collections of grey matter are called the **nucleus gracilis** and **nucleus cuneatus** respectively. The fibres of the two funiculi terminate at intervals in ramifications which are intimately connected with the cells of these nuclei. External to the funiculus cuneatus, between it and the fasciculi of the spinal accessory nerve, there is a third funiculus which is not represented in the posterior column of the spinal cord. It is called the **funiculus of Rolando,** and is caused by the substantia gelatinosa of Rolando coming close to the surface in the lower half of the medulla, and giving rise to a longitudinal elevation. Inferiorly it is narrow, but superiorly it expands and terminates in an enlarged extremity, called the **tubercle of Rolando.** The delicate layer of longitudinal fibres covering the funiculus of Rolando represents the spinal or ascending root of the fifth cranial nerve.

The *upper portion* of the posterior area presents, on either side, a round tract, called the **restiform body,** which is situated between the lateral margin of the lower half of the floor of the fourth ventricle and the fasciculi of the pneumogastric and glosso-pharyngeal nerves. Its direction is upwards, outwards, and backwards into the corresponding hemisphere of the cerebellum, of which it constitutes the *inferior peduncle.* It derives its fibres from the following sources: (1) the direct cerebellar tract of the lateral column of the spinal cord; (2) the anterior superficial arcuate fibres, which emerge from the anterior median fissure of the medulla; (3) the posterior superficial arcuate fibres, which arise from the cells of the nucleus gracilis and nucleus cuneatus; and (4) the cerebello-olivary fibres, to be presently described. The restiform body is the great tract of communication between the medulla oblongata and spinal cord on the one hand and the cerebellum on the other.

Arcuate Fibres of the Medulla.—These fibres are arranged as superficial and deep, but the former only will be described here. The **superficial arcuate fibres** are arranged in two sets, anterior and posterior. The *anterior superficial arcuate fibres* emerge from the anterior median fissure, and curve outwards over the pyramid, the lower part of the olivary body, and the adjacent lower portion of the lateral area of the medulla. Thereafter they pass backwards and upwards into the restiform body. The *posterior superficial*

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arcuate fibres, as just stated, arise from the cells of the nucleus gracilis and nucleus cuneatus, and, like the anterior, enter the restiform body.

Summary.—The medulla oblongata is composed of two symmetrical halves, separated superficially by the anterior and posterior median fissures, the former traversing its whole extent, and the latter being confined to its lower half. It is entirely closed in front, but posteriorly it is divisible into a *closed part*, representing the lower half, and an *open part*, representing the upper half. Over the open portion the grey matter comes to the surface, and forms the lower half of the floor of the fourth ventricle. Each half of the medulla presents two sulci—antero-lateral and postero-lateral. The antero-lateral sulcus gives exit to the fasciculi of the hypoglossal nerve, and in line with these superiorly is the sixth cranial nerve. The postero-lateral sulcus transmits the fasciculi of the spinal accessory, pneumogastric and glosso-pharyngeal nerves, in this order from below upwards. Above these are the seventh or facial and eighth or auditory nerves, the facial being the internal of the two, and the pars intermedia of Wrisberg intervenes between it and the auditory. By means of the two sulci just stated, with the corresponding nerve-fasciculi, each half of the medulla is divided into three areæ—anterior, lateral, and posterior. The **anterior area** forms the pyramid, which inferiorly is disposed as the direct and crossed pyramidal tracts. The fibres of the direct pyramidal tract are continued into the anterior column of the spinal cord of the same side, where they lie close to the anterior median fissure, and form the direct or anterior pyramidal tract, or column of Türck. The fibres of the crossed pyramidal tract sweep across the lower part of the anterior median fissure, and then descend in the posterior part of the lateral column of the spinal cord of the opposite side, of which they constitute the crossed or lateral pyramidal tract. The intercrossing of the fibres of the pyramids in the lower part of the anterior median fissure of the medulla constitutes the decussation of the pyramids. Above this decussation each pyramid is crossed in an outward direction by the anterior superficial arcuate fibres. The **lateral area** is subdivided into two parts—upper and lower. The upper part is occupied by the olivary body, and the lower part (lateral tract) by a strand of fibres derived from the tract of Gowers and the lateral basis bundle of the lateral column of the spinal cord of the same side. The lower part of the olivary body and the adjacent portion of the lateral tract are crossed by the anterior superficial arcuate fibres. The **posterior area** of the medulla is subdivided into two parts—lower or closed, and upper or open. The closed part, on each side, consists of the following strands, named in order from the posterior median fissure outwards: (1) funiculus gracilis, ending superiorly in the clava, and having the nucleus gracilis subjacent to it; (2) funiculus cuneatus, ending superiorly in the cuneate tubercle, and having the nucleus cuneatus subjacent to it; and (3) the funiculus of Rolando, ending superiorly in the tubercle of Rolando, and having superficial to it the fibres of the spinal or ascending root of the fifth nerve. The open part of the posterior area presents, on either side, the restiform body.

The superficial arcuate fibres are arranged in two sets—anterior, which emerge from the anterior median fissure and curve outwards to the restiform body, and posterior, which arise from the cells of the nucleus gracilis and nucleus cuneatus, and likewise enter the restiform body.

Internal Structure of the Medulla.—The medulla oblongata is composed of two kinds of nervous matter, white and grey, the white being disposed chiefly on the surface, and the grey in the interior, except over the lower half of the floor of the fourth ventricle, where it comes to the surface.

The principal superficial longitudinal tracts of **white matter** on either side are the pyramid, funiculus gracilis, funiculus cuneatus,

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and restiform body, all of these being associated with the spinal cord. There are, however, other longitudinal strands which are peculiar to the medulla, the chief of which are the fillets or lemnisci, right and left.

A large part of the **grey matter** is arranged as the formatio reticularis, but it also exists as (1) a thick layer around the central canal in the closed part of the medulla, and on the floor of the fourth ventricle in the open part; (2) the substantia gelatinosa of Rolando; (3) the nuclei graciles; (4) the nuclei cuneati; (5) the inferior olivary nuclei; and (6) the arcuate nuclei.

Lower or Closed Part of the Medulla.—An important change in the internal structure of this part is produced by the decussation of

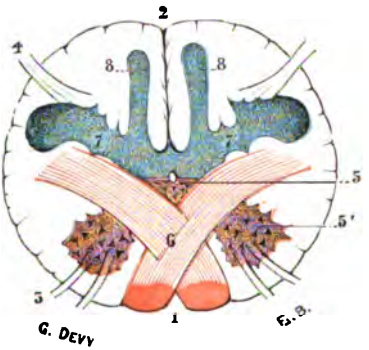

FIG. 545.—SECTION OF THE MEDULLA OBLONGATA AT THE LEVEL OF THE DECUSSATION OF THE PYRAMIDS (L. TESTUT'S 'ANATOMIE HUMAINE').

1. Anterior Median Fissure
2. Posterior Median Fissure
3. Motor Roots
4. Sensory Roots
5. Base of the Anterior Cornu from which the Caput, 5', has been detached by the passage of the crossed Pyramidal Tract
6. Decussation of the crossed Pyramidal Tracts
7. Posterior Cornu
8. Nucleus Gracilis

the pyramids. The fasciculi of the crossed pyramidal tract pass through the anterior grey cornu of the cord, and then cross the anterior median fissure of the medulla to the opposite pyramid. The anterior grey cornu is thus broken up, and its caput becomes separated from its basal part. The basal part remains on the ventral and lateral aspects of the central canal. The detached caput, being displaced laterally, and thus coming close to the caput cornu posterioris, is broken up into a network of grey matter, containing nerve-cells, and traversed by white fibres. This network is known as the **formatio reticularis.** The posterior grey cornu also becomes displaced laterally by the increase in size of the funiculus gracilis and funiculus cuneatus, and it comes to lie at right angles to the posterior median fissure. Its caput undergoes enlargement, and lies close to the surface, and the substantia gela-

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tinosa of Rolando gives rise to the funiculus and tubercle of Rolando. The basal part of the posterior grey cornu remains on the dorsal and lateral aspects of the central canal; but its cervix becomes intersected by variously-disposed fibres, and is thus broken up, like the caput of the anterior grey cornu, into a formatio reticularis. This formatio reticularis cuts off the caput cornu posterioris from the rest of the grey matter, and it joins the formatio reticularis formed in the caput cornu anterioris.

The grey matter of the nucleus gracilis is an extension of the grey matter of the base of the posterior cornu. The nucleus gracilis terminates just above the level of the calamus scriptorius. The grey matter of the nucleus cuneatus is originally an extension

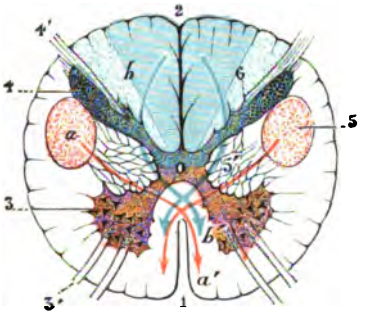

FIG. 546.—SECTION OF THE MEDULLA OBLONGATA THROUGH THE LOWER PART OF THE DECUSSATION OF THE PYRAMIDS (L. TESTUT'S 'ANATOMIE HUMAINE').

1. Anterior Median Fissure
2. Posterior Median Fissure
3. Anterior Cornu
3. Anterior Nerve-roots
4. Posterior Cornu
4. Posterior Nerve-roots
5. Crossed Pyramidal Tract
6. Column of Burdach

The red arrows, *a*, *a'*, indicate the paths taken by the crossed Pyramidal Tracts at the level of the decussation of the Pyramids; and the blue arrows, *b*, *b'*, indicate the paths of the Sensory Fibres.

of the grey matter of the base of the posterior cornu. This nucleus extends a little higher than the nucleus gracilis. The fibres of the funiculus gracilis and funiculus cuneatus, as has been stated, terminate at intervals in ramifications which are intimately connected with the cells of these two nuclei. External to the nucleus cuneatus there is an additional collection of grey matter, known as the *accessory* or *external cuneate nucleus*.

Deep Arcuate Fibres.—These fibres arise from the cells of the nucleus gracilis and nucleus cuneatus on their deep aspects. They pass forwards and inwards in a curved manner to the median raphé of the medulla. Here they cross to the opposite side, decussating with those which come from that side immediately above the level of the decussation of the pyramids, but on a more posterior plane. This intercrossing is known as the **sensory de-**

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cussation (decussation of the fillets), as distinguished from the decussation of the pyramids, which is known as the **motor decussation.** Having crossed the median line, the deep arcuate fibres give rise to a well-marked longitudinal tract, which is called the **fillet,** or *lemniscus.* This tract is situated immediately behind the pyramid, lying between it and the posterior longitudinal bundle which contains the anterior ground-bundle of the anterior column of the spinal cord. The order of these longitudinal tracts, from before backwards, is as follows: (1) pyramid, (2) fillet, and (3) posterior longitudinal bundle.

Posterior Longitudinal Bundle.—This is situated behind the fillet, and its fibres, to a large extent, are derived from the anterior ground-

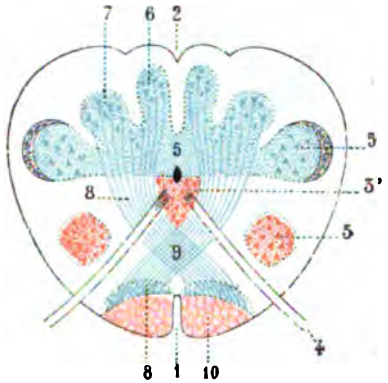

FIG. 547.—TRANSVERSE SECTION PASSING THROUGH THE SENSORY DECUSSATION (SCHEMATIC) (L. TESTUT'S 'ANATOMIE HUMAINE').

1. Anterior Median Fissure
2. Posterior Median Fissure
3, 3¹. Caput and Base of Anterior Cornu (in red)
4. Hypoglossal Nerve
5, 5. Caput and Base of Posterior Cornu
6. Nucleus Gracilis
7. Nucleus Cuneatus
8, 8. Fillet, or Sensory Tract
9. Sensory Decussation
10. Pyramidal Tract

bundle of the anterior column of the spinal cord of the same side. As a result of the decussation of the pyramids, the anterior ground-bundle is displaced backwards.

Olivary Nuclei.—These collections of grey matter are three in number, namely, inferior, mesial, and dorsal accessory. The **inferior olivary nucleus** is situated within the olivary body. When a transverse section of that body is made, the nucleus appears as a wavy lamina of grey matter, so disposed as to constitute an incomplete capsule which encloses white matter. The deficient part of the lamina is known as the *hilum,* and it looks towards the median line. Large numbers of white fibres pass through it, which form the *olivary peduncle.* The **mesial** and **dorsal accessory olivary nuclei** are two small grey bands, which are situated on the mesial and

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dorsal aspects of the inferior olivary nucleus. The grey matter of these three olivary nuclei contains many nerve-cells. Some of the fibres related to the nuclei terminate in these cells, but others pass through the grey matter.

Upper or **Open Part of the Medulla—Restiform Body.**—This takes the place superiorly of the funiculus gracilis and funiculus cuneatus. Its direction is upwards, outwards, and backwards into the hemisphere of the cerebellum, of which it constitutes the inferior peduncle. It becomes conspicuous above the limit of the cuneate tubercle, and forms the lateral boundary of the lower part of the floor of the fourth ventricle. Its fibres are derived from the following sources: (1) the direct cerebellar tract; (2) the anterior superficial arcuate fibres; (3) the posterior superficial arcuate fibres; and (4) the cerebello-olivary fibres. The *direct cerebellar tract*, as it approaches the olivary body, passes obliquely backwards, and its fasciculi, having covered the tubercle of Rolando, enter the outer part of the restiform body. The *anterior superficial arcuate fibres* of one side arise from the lower parts of the nucleus gracilis and nucleus cuneatus of the opposite side, where they really belong to the internal or deep arcuate fibres. With these latter they cross at the median raphé, decussating with their fellows of the opposite side. Instead, however, of entering the fillet, they pass forwards in the anterior median fissure, and then curve outwards over the pyramid, the lower part of the olivary body, and the adjacent portion of the lateral tract, after which they enter the restiform body. A few of the anterior superficial arcuate fibres may pass through the pyramid, or may appear between it and the olivary body. The *posterior superficial arcuate fibres* arise from the nucleus gracilis and nucleus cuneatus, and enter the restiform body of the same side, whilst, as stated, the anterior superficial arcuate fibres cross to enter the restiform body of the opposite side.

The *cerebello-olivary fibres* enter largely into the formation of the restiform body, of which they constitute the deep part. They represent the fibres of the olivary peduncle of either side, and they emerge in large numbers through the hilum of the inferior olivary nucleus. They then cross at the median raphé, and pass through or around the inferior olivary nucleus of the opposite side. Thereafter they pass backwards into the deep part of the restiform body, through which they course to the cortex of the cerebellum, where they are regarded as arising, (it may be from the cells of Purkinje). The cerebello-olivary fibres are therefore to be regarded as centrifugal or efferent fibres passing from the cells of the cerebellar cortex of one side to the cells of the inferior olivary nucleus of the opposite side.

The **arcuate nucleus** is of small size, and is situated partly in front of the pyramid under cover of the anterior superficial arcuate fibres, just above the decussation of the pyramids, and partly, at a higher level, on the inner side of the pyramid, close to the anterior median fissure. Some of the anterior superficial arcuate fibres are

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regarded as terminating in its cells, and others of these fibres as arising from its cells.

Formatio Reticularis of the Medulla.—This is situated behind the pyramid and the olivary body. It is divided into two parts, lateral and mesial, by the fasciculi of the hypoglossal nerve on their way to the antero-lateral sulcus. The *lateral* portion is situated behind the olivary body, and is called the **formatio reticularis**

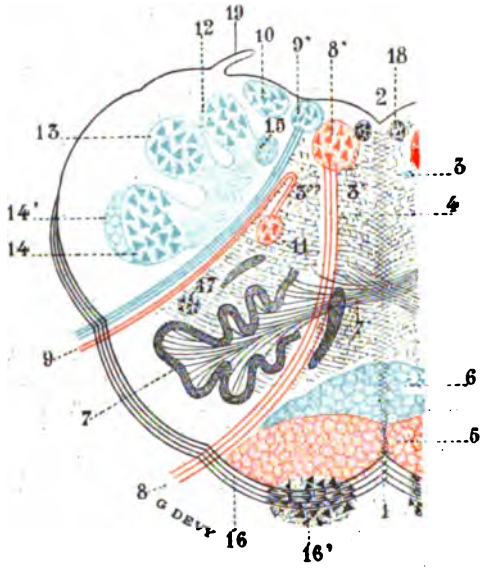

FIG. 548.—THE FORMATIO RETICULARIS OF THE MEDULLA OBLONGATA, SHOWN BY A HORIZONTAL SECTION PASSING THROUGH THE MIDDLE OF THE OLIVARY BODY (DEMI-SCHEMATIC) (L. TESTUT'S 'ANATOMIE HUMAINE').

1. Anterior Median Fissure
2. Fourth Ventricle
3. Formatio Reticularis
3'. Reticularis Alba
3''. Reticularis Grisea
4. Raphé
5. Anterior Pyramid
6. Fillet
7. Inferior Olive, with the two Accessory Nuclei
7'. Peduncle of Olivary Body
8. Hypoglossal Nerve
8'. Hypoglossal Nucleus
9. Pneumogastric Nerve
9'. Terminal Nucleus of Pneumogastric Nerve
10. External Dorsal Auditory Nucleus
11. Nucleus Ambiguus
12. Nucleus Gracilis
13. Nucleus Cuneatus
14. Caput of Posterior Cornu
14'. Lower Sensory Root of Fifth Nerve
15. Fasciculus Solitarius
16. External Anterior Arcuate Fibres
16'. Arcuate Nucleus
17. Lateral Nucleus
18. Nucleus of Fasciculus Teres

grisea (grey formation), from the large amount of grey matter and nerve-cells which it contains. Its grey matter is continuous with that of the formatio reticularis of the spinal cord. The *mesial* portion is situated behind the pyramid, and is called the **formatio reticularis alba** (white formation). It contains very little grey matter and only a few nerve-cells. Both divisions of the formatio reticularis are intersected by nerve-fibres, arranged transversely and longitudinally. The *transverse fibres* are the internal or deep

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arcuate fibres on their way to the sensory decussation, or decussation of the fillets, at the median raphé. The *longitudinal fibres* are disposed in two groups. Those which traverse the formatio grisea are mainly derived from the tract of Gowers and the lateral ground-bundle of the spinal cord; and those which pass through the formatio alba belong to the fillet and the posterior longitudinal bundle.

Raphé of the Medulla.—The raphé occupies the median line, and is composed of fibres which pass in various directions, as they cross from side to side. It contains numerous multipolar nerve-cells.

Central Canal of the Medulla.—This occupies the closed or lower part of the medulla. As it ascends it is gradually displaced backwards by the decussation of the pyramids and the sensory decussation or decussation of the fillets. It is surrounded by a thick layer of grey matter, which is continuous with the basal portions of the anterior and posterior grey cornua of the spinal cord. Superiorly, at the level of the calamus scriptorius, it opens into the fourth ventricle at its lower pointed end; and the surrounding grey matter becomes spread out upon the ventricular floor, where it is covered by ependyma.

Areæ of the Medulla.—The three areæ—anterior, lateral, and posterior—which have been already described as regards the structures which they present superficially, are clearly seen in their entire extent only when transverse sections of the medulla have been made. The divisions into areæ are effected by the fasciculi of the hypoglossal and pneumogastric nerves, after their fibres leave their nuclei of origin in the lower or medullary portion of the floor of the fourth ventricle. The **anterior area** lies between the hypoglossal fasciculi and the median raphé; the **lateral area** intervenes between the hypoglossal and pneumogastric fasciculi; and the **posterior area** is situated behind the pneumogastric fasciculi.

Relation of Chief Nerve-fasciculi of the Spinal Cord to the Medulla Oblongata.

Spinal Cord (Posterior Column).		Medulla Oblongata.
Column of Goll	=	Funiculus Gracilis.
Column of Burdach	=	Funiculus Cuneatus.
Spinal Cord (Lateral Column).		**Medulla Oblongata.**
Direct Cerebellar Tract	=	Restiform Body.
Tract of Gowers and Lateral Ground-bundle	=	Lateral Tract below Olivary Body.
Crossed Pyramidal Tract	=	Inner three-fourths of Opposite Pyramid.
Spinal Cord (Anterior Column).		**Medulla Oblongata.**
Direct Pyramidal Tract (Column of Türck)	=	Outer fourth of Pyramid of same Side.
Anterior Ground-bundle	=	Posterior Longitudinal Bundle of same Side.

Development.—The medulla oblongata is developed as a thickening of the wall of the myelencephalon, which is one of the divisions of the rhombencephalon.

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2. The Pons Varolii.

The **pons Varolii** is situated above the medulla oblongata, and between the hemispheres of the cerebellum. With the exception of the restiform bodies, all the other parts of the medulla oblongata are prolonged into it. The pons presents two surfaces, ventral and dorsal, and two borders, upper and lower. The **ventral surface** rests upon the upper part of the basilar groove of the occipital bone and the dorsum sellæ of the sphenoid. It is convex from side to side, and from above downwards, and has a transversely-striated appearance, due to the disposition of its superficial fibres. Along the median line it presents the *basilar groove*, which extends from the lower to the upper border, and lodges the basilar artery. On either side of this groove the ventral surface is rendered prominent by the prolongation upwards of the pyramids of the medulla oblongata, and the basilar groove is chiefly due to this circumstance. The sensory and motor roots of the fifth nerve, lying close together, appear on the lateral aspect of the ventral surface, the small motor root being the upper of the two. The portion external to these two nerve-roots constitutes the middle peduncle of the cerebellum. It is composed of the transverse fibres of the pons, these on either side being collected into a large bundle, which passes backwards and outwards into the corresponding cerebellar hemisphere.

The **dorsal surface** is directed towards the cerebellum, and is flat. It is covered by grey matter, and is continuous with the dorsal surface of the open or upper part of the medulla oblongata. It forms the upper part of the floor of the fourth ventricle, and will be described in connection with that space. Suffice it to say in the meantime that it presents, on either side of the median line, (1) the fovea superior, (2) the eminentia teres, (3) a prolongation of the area acustica, (4) the locus cæruleus, and (5) the substantia ferruginea. The superior peduncles of the cerebellum, as they pass upwards, lie on the dorsal surface. The grey matter on the dorsal surface is covered with ependyma.

The **upper border** is arched, rising higher at the centre than laterally, and the two crura cerebri emerge from it. The **lower border** is straight, and the sixth, seventh or facial, and eighth or auditory, nerves are met with at this border in the order named from within outwards.

Internal Structure of the Pons Varolii.—The pons is composed of a large ventral and a small dorsal part.

Ventral Part.—This portion consists of: (1) bundles of transverse fibres, (2) bundles of longitudinal fibres, and (3) a large amount of grey matter.

The **bundles of transverse fibres** intersect the bundles of longitudinal fibres, and on either side they are collected into the middle peduncle of the cerebellum, which enters the corresponding cerebellar hemisphere. Some of the transverse fibres arise in the cortex of the cerebellum as the axons of the cells of Purkinje, and these

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terminate in the pons in arborizations around the cells of the *nucleus pontis*, mostly on the opposite side to that on which they arise. Other transverse fibres arise in the pons as the axons of the cells of the nucleus pontis on one side. They then cross to the other side, and enter the cerebellar hemisphere of that side, where they terminate in arborizations in the cortex. The fibres, therefore, of which the middle peduncle of the cerebellum is composed may be regarded as being of two kinds, namely, efferent and afferent. The efferent fibres arise in the cerebellar cortex and terminate in the pons, whilst the afferent fibres arise in the pons and terminate in the cerebellar cortex.

The **bundles of longitudinal fibres** are derived from the breaking up of the pyramids of the medulla oblongata as they sink into the pons. At the upper border of the pons they yre collected together and form the two crura cerebri. The longitudinal bundles which enter the pons from above are more numerous than those which leave it below in the pyramids, the explanation being that some fibres terminate in the pons in arborizations around the cells of the nucleus pontis.

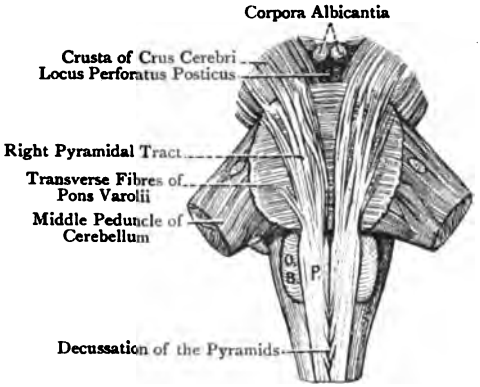

FIG. 549.—DISSECTION OF THE PONS VAROLII, SHOWING THE COURSE OF THE PYRAMIDAL TRACTS OF THE MEDULLA OBLONGATA (HIRSCHFELD AND LEVEILLÉ).

P, Right Pyramid; O.B., Right Olivary Body.

The **grey matter** of the pons, which is large in amount, occupies the intervals between the intersecting transverse and longitudinal bundles, and contains small multipolar nerve-cells. It is known as the *nucleus pontis*, and is continuous with the arcuate nuclei of the medulla oblongata.

Corpus Trapezoides. — This represents a group of transverse fibres which have no connection with the middle peduncles of the cerebellum. The group is situated in the lower part of the pons. Its fibres arise partly from the cells of the central or accessory nucleus of the cochlear division of the auditory nerve, and partly from those of the superior olivary nucleus. Some of the fibres end in the superior olivary nucleus. Others cross the median line to the opposite side and enter the lateral fillet, the fibres of which terminate in the inferior quadrigeminal body and internal geniculate body of that side.

Dorsal or **Tegmental Part of the Pons.**—This portion is divided

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into two symmetrical halves by a median raphé, which is an upward continuation of that of the open part of the medulla oblongata. The dorsal part is principally composed of a prolongation of the formatio reticularis of the medulla. Inferiorly, in the region of the corpus trapezoides there are important tracts of nerve-fibres, and collections of grey matter from which important nerves arise. These will now be described in order from without

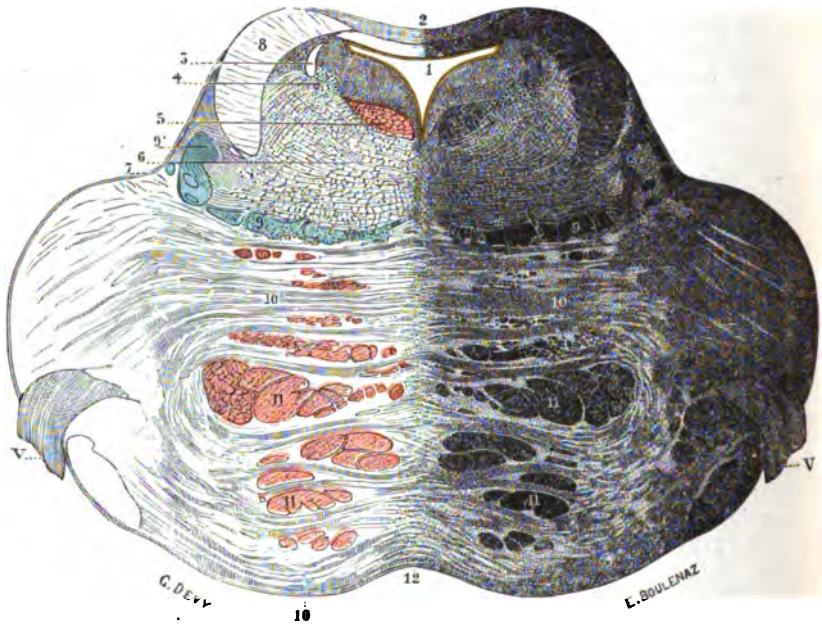

FIG. 550.—VERTICAL TRANSVERSE SECTION THROUGH THE UPPER PART OF THE PONS VAROLII (FROM L. TESTUT'S 'ANATOMIE HUMAINE,' AFTER STILLING).

1. Fourth Ventricle
2. Valve of Vieussens
3. Superior Root of Fifth Nerve
4. Nerve-cells which accompany this Root
5. Posterior Longitudinal Bundle
6. Formatio Reticularis
7. Lateral Fissure of Isthmus
8. Section of Superior Cerebellar Peduncle
9, 9'. Mesial and Lateral Portions of the Fillet
10, 10. Transverse Fibres of the Pons
11, 11. Longitudinal Fibres of the Pons
12. Raphé
V. Fifth Nerve

inwards on either side. (1) The fasciculi of the spinal or ascending root of the fifth nerve lie externally on the inner side of the restiform body, the vestibular root of the auditory nerve intervening between the two. (2) The nucleus of the facial nerve is next in order. It is deeply situated in the dorsal part of the pons in close proximity to the fibres of the corpus trapezoides, and behind the superior olivary nucleus. The fibres of the facial nerve, having

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arisen from the cells of the facial nucleus, pass backwards and inwards towards the grey matter on the floor of the fourth ventricle. Here they are collected into one bundle which traverses the pons in a forward and outward direction on the outer side of the facial nucleus, to the place where the nerve makes its superficial appearance. (3) The superior olivary nucleus is situated internal to, but deeper than, the facial nucleus, and behind the fibres of the corpus trapezoides, some of which enter it, whilst others are derived from it. (4) The nucleus of the sixth nerve consists of a group of multipolar cells, which lie close beneath the floor of the fourth ventricle in the region of the upper part of the eminentia teres. The fasciculi of the nerve pass forwards and downwards to the lower border of the pons, where the nerve emerges. (5) The posterior longitudinal bundle and the fillet are internal to the nucleus of the sixth nerve, and they lie close to the median raphé. The posterior longitudinal bundle is posterior in position—that is to say, nearest the floor of the fourth ventricle—and it receives nerve-fibres from the nucleus of the sixth nerve.

Above the level of the corpus trapezoides the dorsal part of the pons also presents important structures. (1) The nuclei of the fifth nerve are two in number, motor and sensory. The **motor nucleus** is situated close to the lateral margin of the upper part of the floor of the fourth ventricle, where it lies near the dorsal surface of the pons. The **sensory nucleus** is situated on the outer side of the motor nucleus, and is more deeply placed. It is here joined from below by the fibres of the spinal or ascending root of the nerve. Above these two nuclei a descending tract of nerve-fibres makes its appearance close to the inner aspect of the superior peduncle of the cerebellum. These fibres constitute the descending root of the fifth nerve, and they join the motor part of the nerve. They arise from the lateral portion of the grey matter which surrounds the aqueduct of Sylvius. The roots of the fifth nerve traverse the ventral part of the pons, from which they emerge close to the middle peduncle of the cerebellum.

(2) The posterior longitudinal bundle is continued upwards through the upper portion of the dorsal part of the pons, and maintains its position close to the median raphé.

(3) The fillet is prolonged upwards, lying on the ventral aspect of the posterior longitudinal bundle, and it is now known as the **mesial fillet.**

(4) The **lateral fillet** derives its fibres largely from the corpus trapezoides, and it lies external to the mesial fillet.

(5) The nucleus of the lateral fillet is a small collection of grey matter, which lies between the mesial and lateral fillets. It is regarded as being continuous with the superior olivary nucleus.

(6) The superior peduncle of the cerebellum lies on the outer side of the floor of the fourth ventricle.

Development.—The pons Varolii is developed as a thickening of the ventral and lateral walls of the metencephalon, which is one of the divisions of the rhombencephalon.

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3. The Cerebellum.

The cerebellum, or small brain, occupies the inferior occipital or cerebellar fossæ of the occipital bone. It lies beneath the posterior parts of the hemispheres of the cerebrum, from which it is separated by a septum of the dura mater, called the tentorium cerebelli, and it is posterior to the medulla oblongata and pons Varolii. It is composed of white and grey matter, the white matter being situated in the interior, where it constitutes the medullary substance, and the grey matter being spread over the surface as the cortex. In appearance it is laminated or foliated, the laminæ being separated from each other by parallel, slightly curved sulci. It is composed of two large lateral portions, called **hemispheres,** and a connecting median portion, termed the **vermis** ('worm') or **vermiform process,** these parts being much more distinctly demarcated below than above. It presents, in the median line, two notches, anterior and posterior. The **anterior notch,** which is wide, is known as the *incisura semilunaris*, and it contains the inferior pair of quadrigeminal bodies and the superior cerebellar peduncles. The **posterior notch** is narrow, and is occupied by the falx cerebelli. The most conspicuous sulcus of the cerebellum is the **great horizontal fissure,** which extends round the circumference, and passes for some distance into the interior. By means of this fissure the cerebellum is divided into two parts, upper and lower.

Upper Surface of the Cerebellum.—This surface presents in the median line the upper part of the vermis, known as the **superior vermis.** It extends from the incisura semilunaris to the posterior notch, and it forms a laminated elevation, which is higher in front than behind, the most prominent part being known as the *monticulus cerebelli*. On either side of the superior vermis the upper surface of each hemisphere inclines downwards to the circumference, and there is no distinct demarcation between it and the superior vermis.

The **superior vermis** is composed of five lobules, named, in order from before backwards, the lingula, central lobule, culmen monticuli, clivus monticuli, and folium cacuminis. The **lingula** is deeply placed, and consists of about four laminæ or folia, which lie over the superior medullary velum as it extends between the superior cerebellar peduncles. Its laminæ may be continued on either side over the superior cerebellar peduncle, and, when this is so, the prolongation is known as the **frenulum linguæ.**

The **central lobule** is of small size, and lies at the bottom of the incisura semilunaris. It is separated from the lingula by the precentral fissure, and from the culmen monticuli by the post-central fissure.

The **culmen monticuli** forms the summit of the superior vermis. It is composed of several laminæ, and posteriorly is separated from the clivus by the preclival fissure.

The **clivus monticuli** represents the sloping part of the monticulus

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cerebelli. It is situated behind the culmen monticuli, and is composed of several laminæ. Posteriorly it is separated from the folium cacuminis by the postclival fissure.

The **folium cacuminis** forms the posterior extremity of the superior vermis, and lies at the posterior notch, where it is placed above the great horizontal fissure.

The **upper surface of each hemisphere** is mapped out into lobules, which are continuous with the subdivisions of the superior vermis, with the exception of the lingula. These are called, in order from before backwards, the ala, anterior crescentic lobule, posterior crescentic lobule, and postero-superior lobule.

The *ala* is continuous with the central lobule, from which it is

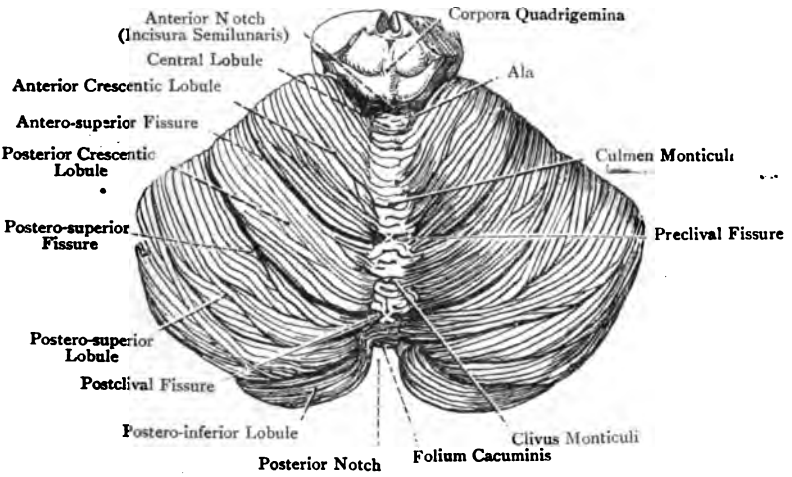

FIG. 551.—THE CEREBELLUM (SUPERIOR VIEW).

prolonged for a limited distance round the anterior part of the hemisphere in the region of the incisura semilunaris.

The *anterior crescentic lobule* is continuous with the culmen monticuli, and represents the anterior subdivision of the upper surface of the cerebellar hemisphere. It is limited posteriorly by a curved sulcus, called the *antero-superior fissure*, which is continuous with the *preclival fissure*, and opens at the circumference into the great horizontal fissure. The right and left anterior crescentic lobules, together with the culmen monticuli, form the **lobus culminis.**

The *posterior crescentic lobule* is continuous with the clivus monticuli. It is limited in front by the *antero-superior fissure*, and behind by the *postero-superior fissure*, the latter being continuous with the *postclival fissure*, and opening at the circumference into the great horizontal fissure. The right and left posterior

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crescentic lobules, together with the clivus monticuli, form the **lobus clivi.**

The *postero-superior lobule* (superior semilunar lobule) corresponds to, but is much more extensive than, the folium cacuminis. It is limited in front by the postero-superior fissure, and behind by the great horizontal fissure. The right and left postero-superior lobules, together with the folium cacuminis, form the **lobus cacuminis.**

Under Surface of the Cerebellum.—The under surface presents in the median line a deep groove, called the **vallecula,** which is continuous behind with the posterior notch. Anteriorly it lodges the medulla oblongata, and lying in the bottom of it there is the lower part of the vermis, which is known as the **inferior vermis.**

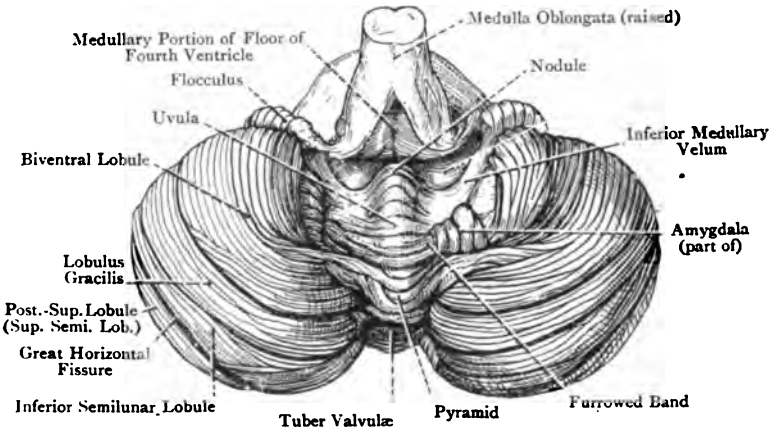

FIG. 552.—THE CEREBELLUM (INFERIOR VIEW).

(The Inferior Semilunar Lobule and the Lobulus Gracilis together constitute the Postero-inferior Lobule).

The vallecula separates the two cerebellar hemispheres from each other, and the inferior vermis is separated on either side from the corresponding hemisphere by a furrow called the *sulcus vallecul*æ. The under surfaces of the hemispheres are markedly convex, and are received into the inferior occipital or cerebellar fossæ of the occipital bone.

The **inferior vermis** is composed of four lobules, named, in order from behind forwards, tuber valvulæ, pyramid, uvula, and nodule.

The **tuber valvulæ** (tuber posticum) forms the posterior part of the inferior vermis, and is composed of several laminæ. On either side it is prolonged into the corresponding hemisphere, and becomes continuous with the postero-inferior lobule. It is the only part of the inferior vermis which is prolonged into the cerebellar hemispheres.

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The **pyramid** is situated in front of the tuber valvulæ. It presents about four laminæ, and is separated by deep sulci from the tuber valvulæ behind and the uvula in front, whilst on either side it is separated from the cerebellar hemisphere by the sulcus valleculæ. Laterally it is connected with the biventral lobule of the hemisphere by means of a faint ridge, but this lies low in the sulcus valleculæ as it crosses it.

The **uvula** is situated in front of the pyramid, and between the amygdalæ or tonsils of the hemispheres. It is triangular, the base being directed backwards, and it consists of several laminæ. It is separated on either side from the hemisphere by the sulcus valleculæ. Laterally its narrow part is connected with the amygdala by a ridge of grey matter, but this lies low in the sulcus

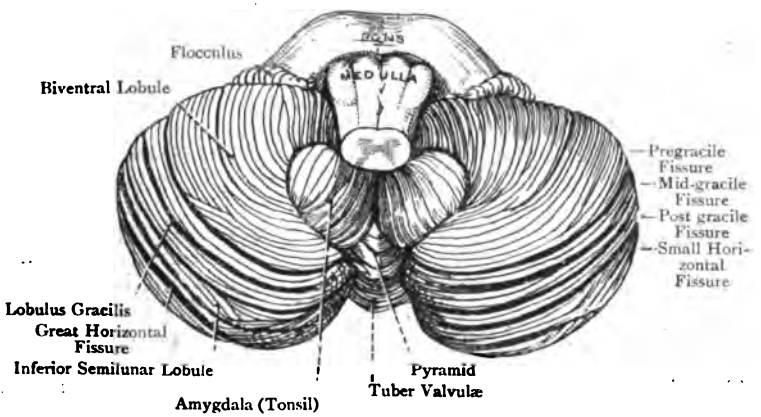

FIG. 553.—THE CEREBELLUM (INFERIOR VIEW).

(The Inferior Semilunar Lobule and the Lobulus Gracilis constitute the Postero-inferior Lobule).

valleculæ as it crosses it. This ridge is notched at intervals, and is called the **furrowed band.**

The **nodule** forms the anterior part of the inferior vermis, and is composed of several laminæ, which are largely concealed by the uvula. It is connected on either side with the flocculus by a thin semilunar band of white matter, which is the lateral portion of the **inferior medullary velum.**

The **fissures** of the inferior vermis are three in number, as follows: *postpyramidal*, between the pyramid and the tuber valvulæ; *prepyramidal*, between the pyramid and the uvula; and *postnodular*, between the nodule and the uvula.

The **under surface of each hemisphere** is mapped out into four lobules, which are called, from behind forwards, the postero-inferior lobule, the biventral lobule, the amygdala, and the flocculus.

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The **postero-inferior lobule** is situated at the back part of the under surface of the hemisphere. It is divided into four curved parts by three curved fissures. The anterior two parts are known as the *lobulus gracilis*, and the posterior two as the *inferior semilunar lobule*. The right and left postero-inferior lobules, together with the tuber valvulæ, form the **lobus tuberis.**

The **biventral lobule** is composed of curved laminæ, and is somewhat triangular. The pointed end is directed backwards and inwards, and it is connected with the pyramid by a faint ridge, which, as stated, lies low in the sulcus valleculæ. The base is directed forwards towards the flocculus. The lobulus gracilis lies external to it, and the amygdala is on its inner side. The biventral lobule is divided by a sulcus into two portions, outer and inner; hence the name 'biventral.' The right and left biventral lobules, together with the pyramid, form the **lobus pyramidis.**

The **amygdala** (tonsil) forms a conspicuous prominence between the uvula and the biventral lobule. It is situated in a depression of the vallecula, which is known as the *nidus avis* ('bird's nest'), and its direction is almost sagittal. It is connected with the narrow part of the uvula by the furrowed band, which, as stated, lies low in the sulcus valleculæ. The right and left amygdalæ, together with the uvula, form the **lobus uvulæ.**

The **flocculus** (subpeduncular lobule) is a small irregular lobule which is situated between the front of the biventral lobule and the middle peduncle of the cerebellum. Internally it is connected with the nodule by the lateral portion of the inferior medullary velum. The right and left flocculi, together with the nodule, form the **lobus nodull.**

The fissures of the under surface of each hemisphere are as follows: (1) a continuation of the postnodular sulcus, between the biventral lobule and the flocculus; (2) a continuation of the prepyramidal sulcus, between the amygdala and the biventral lobule; (3) the pregracile, or anterior arcuate, sulcus, between the biventral lobule and the lobulus gracilis; (4) the mid-gracile, or middle arcuate sulcus, within the lobulus gracilis; (5) the postgracile, or posterior arcuate, sulcus, between the lobulus gracilis and the inferior semilunar lobule; and (6) the small horizontal sulcus within the inferior semilunar lobule.

Peduncles of the Cerebellum.—The peduncles are three in number on either side, namely, superior, middle, and inferior, and they are composed of fibres which enter, or emerge from, the central white medullary substance.

The **superior peduncles** are composed of efferent fibres, and are at first concealed from view by the upper or anterior portions of the hemispheres. After emerging from the hemispheres they pass upwards on the lateral aspects of the dorsal surface of the pons Varolii in a converging manner towards the quadrigeminal bodies. They form the lateral boundaries of the upper part of the floor of the fourth ventricle, and by their convergence they project

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slightly over that part of the ventricle, so as to take part in its roof. The superior medullary velum extends between the two peduncles, and closes the interval between them. On reaching the inferior pair of quadrigeminal bodies the two peduncles pass beneath them and enter the mesencephalon, where their course will be subsequently described (see p. 1331). The most of the fibres of each superior peduncle are derived from the corresponding nucleus dentatus, but a few come from the grey matter of the cerebellar cortex.

The **middle peduncles** are of large size, and re aformed by the transverse fibres of the pons Varolii, these being gathered together on either side into a large bundle, which passes backwards and outwards into the white central medullary substance of the corresponding hemisphere. The fibres of each middle peduncle are both afferent and efferent. The afferent fibres arise in the pons from the cells of the nucleus pontis of the opposite side, and terminate in arborizations around the cells of the cerebellar cortex. The efferent fibres arise from the cells of the cerebellar cortex of the same side, and terminate in arborizations around the cells of the nucleus pontis, mostly on the opposite side.

The **inferior peduncles** constitute the restiform bodies of the medulla oblongata. Each restiform body after leaving the medulla lies for a short distance on the dorsal aspect of the pons Varolii, and thereafter enters the corresponding cerebellar hemisphere. The inferior peduncles are composed of both afferent and efferent fibres. The afferent fibres are chiefly represented by those of the direct cerebellar tracts. They are regarded as terminating in the cortex of the superior vermis, on both sides of the median line, but chiefly on the opposite side. The efferent fibres are mostly represented by the cerebello-olivary fibres. They probably arise in the cortex of the cerebellar hemisphere and superior vermis, and in the nucleus dentatus. For their termination, see p. 1265.

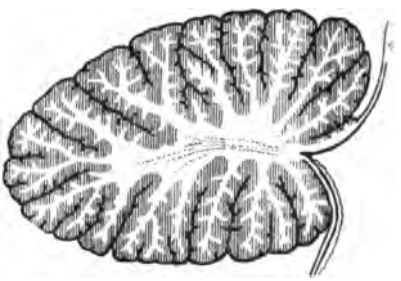

FIG. 554.—SAGITTAL SECTION OF A HEMISPHERE OF THE CEREBELLUM, SHOWING THE ARBOR VITÆ.

White and Grey Matter of the Cerebellum. — In the hemispheres and vermis the white matter is situated in the centre as the medulla, and the grey matter is disposed superficially as the cortex. The white matter in the interior of the vermis is known as the *corpus trapezoides*. When sagittal sections of a hemisphere are made the mass of white matter in the centre is seen to send offshoots into the lobules. From the sides of these offshoots secondary processes are given off, and these in turn furnish tertiary processes, the white

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matter in all cases being covered by grey matter. When the section is made across the direction of the laminæ or folia the appearance presented is like the trunk and branches of a tree : hence the name *arbor vitæ cerebelli* is applied to it.

Nuclei.—The **corpus dentatum** is a collection of grey matter which is situated within the white matter of each hemisphere, and it is similar to the inferior olivary nucleus in the olivary body of the medulla oblongata. It is composed of a wavy grey lamina, disposed in the form of a capsule, which encloses white matter. The capsule presents an opening or *hilum* at its upper and inner part, and through this a large number of the fibres of the superior cerebellar peduncle emerge from the interior.

There are three other nuclei on each side, as follows : (1) the **nucleus emboliformis,** close to the inner side of the hilum of the corpus dentatum ; (2) the **nucleus globosus,** internal to the preceding ; and (3) the **nucleus fastigii,** or roof-nucleus, situated in the corpus trapezoides of the vermis, close to the median line, and contiguous to its fellow of the opposite side.

Commissural and Association Fibres.—The **commissural fibres** pass from the white matter of one hemisphere to that of the opposite hemisphere. They traverse the corpus trapezoides of the vermis in two sets, superior and inferior. The **association fibres** are confined to each side, and they connect adjacent laminæ, passing across the bottom of the fissures which separate them.

Medullary Vela.—These are thin laminæ or curtains of white matter, and are two in number, superior and inferior.

The **superior medullary velum,** or *valve of Vieussens,* is continuous with the corpus trapezoides or white matter of the vermis. It extends between the converging superior cerebellar peduncles, bridging over the interval between them, and becoming continuous with their inner margins. Superiorly it extends to the inferior pair of quadrigeminal bodies, and inferiorly it passes into the corpus trapezoides or white matter of the vermis. It forms a large portion of the roof of the upper part of the fourth ventricle, and its dorsal surface supports the lingula of the superior vermis. From the upper part of the superior medullary velum a band of white fibres, called the *frenulum veli,* passes to the lower part of the median longitudinal groove which separates the lateral pairs of quadrigeminal bodies. Immediately below the inferior pair of quadrigeminal bodies the fourth pair of cranial nerves emerge from the superior medullary velum, on either side of the frenulum veli. The tract of Gowers, after having traversed the formatio reticularis of the medulla oblongata and the dorsal part of the pons Varolii, passes into the superior medullary velum, and then descends in the superior cerebellar peduncle to the cerebellum.

The **inferior medullary velum** is a thin lamina of white matter which is continuous with the white matter of the cerebellum above the nodule of the inferior vermis. On either side of the nodule it

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extends outwards to the flocculus in the form of a delicate semilunar band, and it forms a part of the roof of the fourth ventricle in succession to the superior medullary velum.

Minute Structure of the Cerebellar Laminæ.—Each lamina or folium of the cerebellum consists of (1) a central part or core of white matter, which is an offshoot from the white medullary substance, and (2) an external part or cortex of grey matter.

Grey Cortex.—The **grey cortex** is composed of two layers, an outer **molecular layer,** and an inner **granular layer.** Between these two layers there is a stratum of characteristic large cells, called the cells or corpuscles of Purkinje.

The **cells of Purkinje** are pyriform or flask-shaped, and are situated, as just stated, between the molecular and granular layers. The narrow or superficial end of each cell projects into

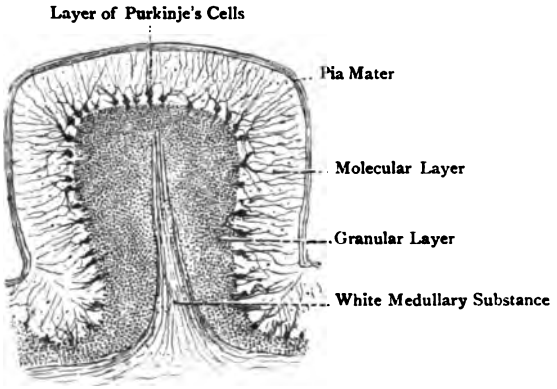

FIG. 555.—STRUCTURE OF A LAMINA OF THE CEREBELLUM (HIGHLY MAGNIFIED).

the molecular layer, and the broad or deep end rests on the granular layer. From the broad or deep end of each cell a single axon passes off, which enters the granular layer, where it soon becomes medullated, and then forms a nerve-fibre of the white medullary substance. The axon of Purkinje's cell gives off a few collateral recurrent branches, some of which end in the granular layer, whilst others enter the molecular layer. From the narrow or superficial end of each cell numerous dendrites are given off. These are at first gathered into one, or it may be two, stems, and after entering the molecular layer these divide and subdivide into a great many ramifying branches, which impart a characteristic arborescent appearance to the arrangement of dendrites. The branches of these dendrites extend through the molecular layer to the surface.

The **molecular layer** consists of fibres and cells. The **fibres** are

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derived from the following sources: (1) the dendrites and the collaterals of the axons of the cells of Purkinje; (2) the dendrites and the axons of the cells in the molecular layer; (3) the axons of the granule-cells in the granular layer; (4) the fibres of Bergmann, derived from the glia-cells in the granular layer, which pass outwards to the surface; and (5) fibres from the white medullary substance of the cerebellum. The **cells** of the molecular layer are arranged in two sets, outer and inner. Each of the outer cells is furnished with an axon and dendrites, the latter branching freely. The inner cells are known as *basket-cells*, and they lie in the vicinity of Purkinje's cells. Each of them is furnished with an axon and dendrites. The axons run transversely between the dendrites of Purkinje's cells, and in their course give off collaterals, which break up into numerous terminal ramifications, arranged in the form of 'baskets,' in which the cells of Purkinje lie.

The **granular layer** is composed of a great number of small granule- or nerve-cells and fibres. The **granule-cells** impart to it a reddish-brown colour; hence the name *rust-coloured layer*. The cells are provided with axons and dendrites. The ramifications of the dendrites terminate in tufts which are closely related to contiguous cells. The axon of each cell enters the molecular layer, in which it passes towards the surface. On approaching the surface each axon divides into two branches, which diverge and pass horizontally between the terminal ramifications of the dendrites of Purkinje's cells, with which they come into close contact. In addition to the small granule-cells there are other large stellate cells, situated in the outer part of the granular layer, near the cells of Purkinje. These are regarded as glia-cells, and they are provided with long branching dendrites. The dendrites enter the molecular layer, in which they extend to the surface as the fibres of Bergmann. At the surface these fibres end in conical enlargements, the broad ends being directed towards the surface. and in this manner a kind of membrana limitans externa is constructed. The axons of the stellate or glia-cells are confined to the granular layer, and are remarkable for their ramifications. These cells may be regarded as belonging to the neuroglia of the cerebellum. The **fibres** of the granular layer are derived from the following sources: (1) the axons of the cells of Purkinje; (2) the moss-fibres of Cajal; and (3) fibres on their way from the white medullary substance to the deep part of the molecular layer.

White Matter of the Cerebellum.—The white matter is composed of medullated nerve-fibres, arranged in bundles, which enter the grey cortex. They terminate in one of three ways. (1) Some become the axons of the cells of Purkinje. (2) Others pass through the granular layer into the molecular layer, where they break up into branches which are closely related to the more deeply placed dendrites of Purkinje's cells. (3) A third set terminate in the granular layer, where they divide into branches which present

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'moss-like appendages,' from which circumstance they are known as the *moss-fibres* (Cajal).

Development.—The cerebellum is developed as a thickening of the dorsal wall of the metencephalon, which is one of the divisions of the rhombencephalon.

4. The Fourth Ventricle.

The fourth ventricle is the space between the medulla oblongata and pons Varolii in front and the vallecula of the cerebellum behind. Inferiorly it is continuous with the central canal of the spinal cord, and superiorly with the aqueduct of Sylvius, by which it communicates with the third ventricle. The floor is rhomboidal or diamond-shaped. The lower angle is called the *calamus scriptorius*, from its resemblance to the point of a writing-pen, and it is at this angle where the central canal of the spinal cord, after traversing the lower or closed part of the medulla oblongata, opens into it. The upper angle is continued into the aqueduct of Sylvius. The ventricle is widest opposite the middle peduncles of the cerebellum, and its lateral angles correspond with this level. In each of these situations it is prolonged outwards round the upper part of the restiform body, this prolongation being called the *lateral recess*. The ventricle presents a dorsal wall or roof and a ventral wall or floor.

Roof of the Fourth Ventricle. — The *upper part* of the roof is formed by the superior medullary velum, as it extends between the converging superior peduncles of the cerebellum, and also to a certain extent by these peduncles, which slightly overhang the space. The *middle part* of the roof is formed by the corpus trapezoides, or white matter of the vermis, into which a portion of the roof extends in a pointed manner. The *lower part* of the roof is formed superiorly by the inferior medullary velum, and below this by a single layer of flattened epithelium, covered by pia mater, the latter being called the *tela choroidea inferior*. The epithelium of the roof becomes continuous with that of the floor, but before this takes place three laminæ of white matter project over it for a short distance, namely, the obex and the two ligulæ, right and left. The **obex** is situated at the lower angle of the floor, where it lies behind the upper opening of the central canal, and covers the point of the calamus scriptorius. The **ligula,** or **tænia,** on either side projects over the epithelium of the roof for a short distance. Externally it is connected with the following structures, from below upwards: the clava, the cuneate tubercle, and the restiform body. Superiorly it passes outwards on the outer aspect of the restiform body, and it here forms the lower boundary of the lateral recess of the ventricle.

Openings in the Roof.—The epithelium and tela choroidea inferior present three openings, one being in the median line and the other two being placed one on each side. The median opening is

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situated a little above the calamus scriptorius, and is called the **foramen of Magendie.** The lateral openings are situated one in the roof of each lateral recess of the ventricle, and are known as the **foramina of Kay and Retzius.** By means of these three openings the cavity of the fourth ventricle communicates with the subarachnoid space.

Choroid Plexuses of the Fourth Ventricle.—These are two in number, and are inflexions of the tela choroidea inferior (pia mater). They carry with them the roof-epithelium, and are disposed somewhat thus, ⅂ ⅂. The vertical portions extend upwards from the foramen of Magendie, lying near the median line, and the transverse portions extend outwards, each projecting into the corresponding lateral recess, but covered by epithelium.

Summary of the Roof.—From above downwards the roof is formed by (1) the superior medullary velum, and superior peduncles of the cerebellum; (2) the corpus trapezoides or white matter of the vermis; (3) the inferior medullary velum; and (4) epithelium, covered by pia mater, the latter being known as the tela choroidea inferior. The laminæ of white matter which project over the roof are the obex in the median line and the two ligulæ, one at either side. The openings in the roof are the foramen of Magendie, and the foramina of Kay and Retzius. The choroid plexuses are two in number, and are inflexions of the tela choroidea inferior (pia mater), which carry the roof-epithelium before them.

Floor of the Fourth Ventricle.—The floor or ventral wall (*fossa rhomboidalis*) is formed in its *lower part* by the dorsal surface of the upper or open part of the medulla oblongata, and in its *upper part* by the dorsal surface of the pons Varolii. It is rhomboidal or diamond-shaped, and is widest opposite the middle peduncles of the cerebellum. The lower pointed portion, between the two clavæ of the medulla, is, as stated, called the *calamus scriptorius*. The entire floor is covered by a thick layer of grey matter, continuous with that which surrounds the central canal of the spinal cord, and of the lower or closed part of the medulla. This grey layer is covered by ependyma (epithelium), the ependymal cells being continuous with those which line the central canal. For convenience the floor is divided into two portions, namely, lower or medullary and upper or pontine.

Lateral Boundaries.—The **lower** or **medullary portion** is bounded laterally by (1) the clava, (2) the cuneate tubercle, and (3) the restiform body, in this order from below upwards. The **upper** or **pontine portion** is bounded laterally by the superior peduncle of the cerebellum.

The floor is traversed in the median line by a slight longitudinal groove, which divides it into two symmetrical halves. On either side of this groove the floor is crossed towards its centre by bundles of fibres, disposed transversely, called **striæ acusticæ.** These fibres apparently emerge from the median groove, and pass outwards over the restiform body. They subdivide each half of the floor into two portions, upper and lower.

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Lower Portion.—This belongs to the medullary area of the floor. Immediately below the striæ acusticæ there is a small triangular depression, called the **fovea inferior.** Its apex is directed towards the striæ, and the lateral angles of its base are prolonged into grooves. The inner groove passes, in a curved manner, towards the point of the calamus scriptorius, and the outer groove passes downwards and outwards to the lateral boundary. Between these two diverging grooves there is a triangular area, called the **trigonum vagi.** Its apex is at the fovea inferior, and its base is directed downwards and outwards. It has a dark colour, and from this circumstance is known as the *ala cinerea.* It contains the nuclei

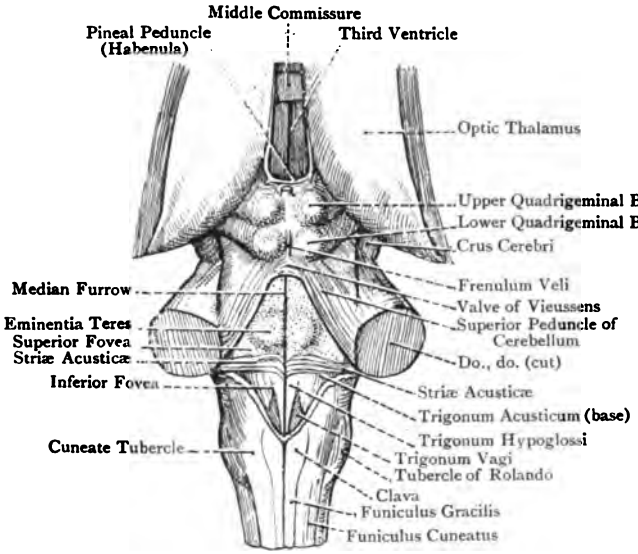

FIG. 556.—THE FLOOR OF THE FOURTH VENTRICLE AND ADJACENT PARTS.

of the vagus and glosso-pharyngeal nerves, the latter being the higher of the two. A second triangular area is situated between the median longitudinal groove on the one hand and the fovea inferior and the inner of the two grooves prolonged from its base on the other hand. This area is called the **trigonum hypoglossi,** and is slightly elevated Its base is directed upwards towards the striæ acusticæ, and its apex looks downwards towards the calamus scriptorius. It contains the nucleus of the hypoglossal nerve. There is still another triangular area, called the **trigonum acustieum.** It is situated between the lateral boundary on the one hand and the fovea inferior and the outer of the two grooves prolonged from its base on the other hand. Its base is directed upwards, and is continued into a prominence, called the **tuber-**

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culum acusticum, over which the striæ acusticæ pass. The trigonum acusticum and tuberculum acusticum represent the *area acustica*, which contains the chief nucleus of the vestibular division of the auditory nerve.

Upper Portion.—The upper portion is situated above the striæ acusticæ, and belongs to the pontine part of the floor. It presents, in line with the fovea inferior, a slight depression, called the **fovea superior.** Between this fovea and the median groove there is a well-marked prominence, called the **eminentia teres.** This is continued inferiorly into the trigonum hypoglossi, and superiorly it can be traced as far as the opening of the aqueduct of Sylvius. Below and external to the fovea superior there is a prominence, produced by

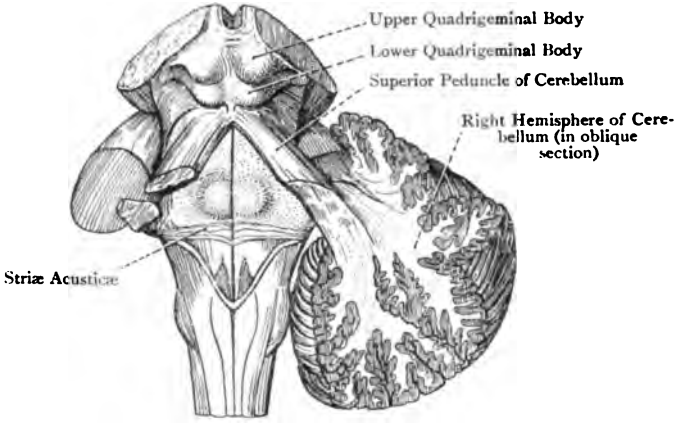

FIG. 557.—THE FOURTH VENTRICLE AND RIGHT HEMISPHERE OF THE CEREBELLUM (IN SECTION) (HIRSCHFELD AND LEVEILLÉ).

the tuberculum acusticum, which extends upwards in this situation. Above the fovea superior, and extending upwards from it to the opening of the aqueduct of Sylvius, there is a slight depression, called the **locus cæruleus,** from its bluish colour. This colour is due to a group of pigmented nerve-cells, known as the **substantia ferruginea.**

Summary of the Floor of the Fourth Ventricle—Lower or **Medullary Portion.**—Each half presents (1) the fovea inferior, (2) the trigonum vagi (ala cinerea), (3) the trigonum hypoglossi, and (4) the trigonum acusticum. **Upper** or **Pontine Portion.**—Each half presents (1) the fovea superior, (2) the eminentia teres, produced by the fasciculus teres, and (3) the locus cæruleus, due to the substantia ferruginea.

Development.—The upper or pontine part of the fourth ventricle is developed from the metencephalon; and the lower or medullary (bulbar) part is developed from the myelencephalon.

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TELENCEPHALON.

Cerebral Hemispheres.

The cerebral hemispheres are two in number, right and left. Each is semi-ovoid, and presents two extremities and three surfaces.

The **extremities** are anterior and posterior. The **anterior extremity** is thick and round, and its most projecting part is called

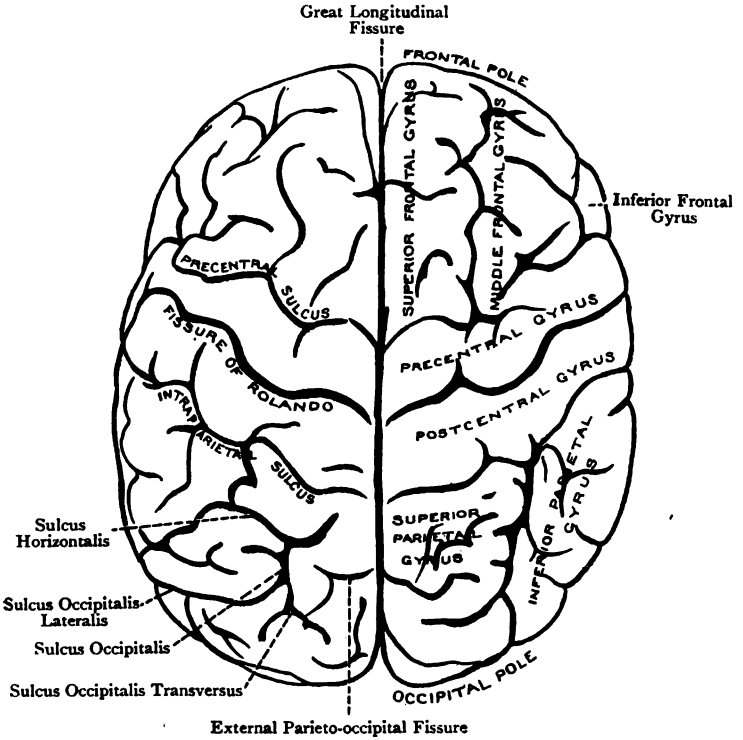

FIG. 558.—THE CEREBRAL HEMISPHERES (SUPERIOR VIEW).

the **frontal pole.** The **posterior extremity** is narrow and pointed, and its most projecting part is called the **occipital pole.** The **surfaces** are external, internal, and inferior. The **external surface** is convex, in adaptation to the concavity of the cranial vault. The **internal surface** is flat and vertical, and it forms the lateral boundary of the great longitudinal fissure. For the most part it is in contact with the falx cerebri. The **inferior surface** is irregular, being adapted to the corresponding lateral divisions of the anterior and middle fossæ of the interior of the base of the skull and the upper

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surface of the tentorium cerebelli. It is crossed transversely by a deep cleft, representing the stem of the fissure of Sylvius. The portion in front of this fissure is known as the *orbital area*, and is concave, in adaptation to the convexity of the orbital plate of the frontal bone, upon which it rests. The extensive portion behind the stem of the Sylvian fissure is known as the *tentorial area*, and is prominent and arched. Its anterior portion is received into the lateral division of the middle cranial fossa, and its posterior portion rests upon the tentorium cerebelli.

The **borders** of each hemisphere are four in number, namely, supero-mesial, infero-lateral, superciliary, and internal occipital. The **supero-mesial border** separates the external from the internal surface. The **infero-lateral border** separates the external surface from the tentorial area of the inferior surface. The **superciliary** border separates the front part of the external surface from the orbital area of the inferior surface. The **internal occipital border** separates the internal surface from the tentorial area of the inferior surface, and it extends from the occipital pole to the splenium of the corpus callosum.

The exterior of each hemisphere is broken up into tortuous eminences, called **gyri** or **convolutions,** and these are separated from each other by clefts, called **sulci** or **fissures.** The exterior is composed of grey matter, which is spoken of as the **cerebral cortex,** and the interior is occupied by white matter, which forms the **medullary centre.** The breaking up of the hemispheres into gyri, with the intervening sulci, greatly increases the amount of cerebral cortex and, to a proportionate extent, of pia mater.

The **fissures** are of two kinds, complete and incomplete. The **complete fissures** are produced by invaginations of the wall of each cerebral vesicle; and the **incomplete fissures** are due to the growth of the gyri.

Each hemisphere presents six principal fissures, called interlobar fissures, and by means of these it is divided into six lobes. The fissures and lobes are as follows:

Interlobar Fissures.	Lobes.
1. Fissure of Sylvius.	1. Frontal.
2. Fissure of Rolando.	2. Parietal.
3. Parieto-occipital.	3. Occipital.
4. Calloso-marginal.	4. Temporal.
5. Collateral.	5. Island of Reil or Insula.
6. Circular or Limiting.	6. Limbic.

Interlobar Fissures.—The **fissure of Sylvius,** which is the first fissure to appear in the course of development, commences on the inferior surface of the hemisphere at the locus perforatus anticus in a depression, called the *vallecula Sylvii*. From this point it passes horizontally outwards to the *Sylvian point* on the external surface of the hemisphere, where it divides into three diverging branches. It is a deep cleft, which is overhung posteriorly by the front part of the temporal lobe, and it separates the orbital surface of the

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frontal lobe from the temporal lobe. The posterior or Sylvian border of the small wing of the sphenoid bone faces the fissure, which lodges the middle cerebral artery. The limbs into which the fissure divides at the Sylvian point are, as stated, three in number, namely, anterior horizontal, anterior ascending, and posterior horizontal. The *anterior horizontal limb* passes forwards into the frontal lobe, its length being about ¾ inch. The *anterior ascending limb* passes upwards and slightly forwards into the frontal lobe for about 1 inch, but its length is variable. The *posterior horizontal limb* is the longest and most conspicuous. It passes backwards on the external surface of the hemisphere for at least 2 inches, having portions of the frontal and parietal lobes above it, and the temporal lobe below it. Finally it turns upwards into the parietal lobe for a very short distance.

The **fissure of Rolando,** also known as the *central sulcus,* commences at the supero-mesial border of the hemisphere, a little behind its mid-point, and terminates above the centre of the posterior horizontal limb of the fissure of Sylvius. It does not usually open into this limb, but may do so. Superiorly the fissure in most cases intersects the supero-mesial border to reach the internal surface of the hemisphere, upon which it passes backwards for a very short distance. The direction of the fissure of Rolando is irregularly downwards and forwards over the external surface of the hemisphere, and it separates the frontal from the parietal lobe. It describes two bends. The *upper genu* has its concavity directed forwards, and is situated about the junction of the upper and middle thirds of the fissure. The *lower genu* has its concavity directed backwards, and is situated on a more anterior plane than the upper genu. Below the lower genu the direction of the fissure is almost vertical, with a slight inclination backwards.

The **parieto-occipital fissure** is situated about 2 inches behind the upper end of the fissure of Rolando, and it separates the parietal from the occipital lobe.. It is composed of two limbs, external and internal, which are continuous with each other at the supero-mesial border of the hemisphere, where they form a right angle. The **external limb** is situated on the external surface of the hemisphere, upon which it passes transversely outwards for about ¾ inch, when it is arrested by the convolution which connects the parietal and occipital lobes. The **internal limb** appears as a deep, almost vertical, cleft on the internal surface of the hemisphere, which opens into the calcarine fissure a short distance behind the splenium of the corpus callosum.

The **calloso-marginal fissure** is situated on the internal surface of the hemisphere. It commences below the rostrum of the corpus callosum, contiguous to the locus perforatus anticus, and, bending round the genu, it passes backwards above the corpus callosum, from which it is separated by the callosal gyrus. At a point a little behind the centre of the internal surface of the hemisphere it turns upwards and terminates at the supero-mesial border, a short distance

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behind the upper end of the fissure of Rolando. The callosomarginal fissure lies between the frontal and limbic lobes, the marginal gyrus being above it and the callosal gyrus below it.

The **collateral fissure** is situated on the inferior surface of the hemisphere. It commences near the occipital pole, and extends forwards to near the temporal pole. Posteriorly it has the calcarine fissure above, and in line with, it, and anteriorly it has the hippocampal gyrus on its mesial side. It separates the temporal lobe from the hippocampal portion of the limbic lobe. The middle

FIG. 559. — THE LEFT CEREBRAL HEMISPHERE (SUPERIOR SURFACE).

Red = Frontal Lobe. Orange = Parietal Lobe. Blue = Occipital Lobe.

portion of the collateral fissure gives rise to the eminentia collateralis in the floor of the lateral ventricle.

The **circular** or **limiting fissure** is situated deeply in the anterior part of the posterior horizontal limb of the fissure of Sylvius. It almost surrounds the convolutions which constitute the island of Reil or insula, and is composed of three parts—superior, inferior, and anterior. The *superior part* separates the insula from the frontal and parietal lobes, the *inferior part* separates it from the temporal lobe, and the *anterior part* separates it from the frontal lobe. The circuar fissure is deficient in the region of the apex of the insula.

Lobes of the Cerebral Hemisphere — Frontal Lobe.—This is of

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large size. On the *external surface* of the hemisphere it is bounded behind by the fissure of Rolando, and below by the posterior horizontal limb of the fissure of Sylvius. On the *inferior surface* it is bounded behind by the stem of the fissure of Sylvius. On the internal surface it is bounded by the calloso-marginal fissure. The frontal lobe has three surfaces—external, inferior, and internal.

External Surface.—This surface presents three principal sulci, namely, precentral, superior frontal, and inferior frontal.

The **precentral sulcus** is more or less parallel to the fissure of Rolando, the ascending frontal or precentral gyrus intervening between the two. It may be a single fissure, but it more frequently consists of two parts, superior and inferior. The *superior part* is usually joined above by the superior frontal sulcus. The *inferior part* passes superiorly into the middle frontal gyrus for a short distance in a forward and upward direction.

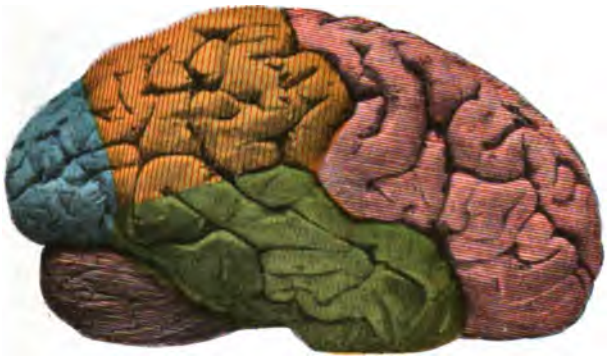

FIG. 560.—THE RIGHT CEREBRAL AND CEREBELLAR HEMISPHERES (EXTERNAL SURFACE).

Red = Frontal Lobe. Blue = Occipital Lobe.
Orange = Parietal Lobe. Green = Temporal Lobe.
Purple = Cerebellar Hemisphere.

The **superior** and **inferior frontal sulci** extend forwards from the precentral sulcus.

The **gyri** of the external surface are as follows: ascending frontal, superior frontal, middle frontal, and inferior frontal.

The **ascending frontal** or **precentral gyrus** is bounded behind by the fissure of Rolando or central sulcus, and in front by the superior and inferior parts of the precentral sulcus. It extends from the supero-mesial border of the hemisphere to a little behind the Sylvian point, which corresponds to the place where the stem of the fissure of Sylvius appears on the external surface of the hemisphere, and divides into its three branches. Below the lower end of the fissure of Rolando it is, as a rule, connected with the ascending parietal or postcentral gyrus by an annectant gyrus.

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The **superior** or *first*, **middle** or *second*, and **inferior** or *third* **frontal gyri** are arranged in tiers, which are disposed antero-posteriorly, the first and second being usually each subdivided, so as to make five tiers in all. They are separated from the ascending frontal or precentral gyrus by the superior and inferior parts of the precentral sulcus.

The **superior frontal gyrus** is narrow, and lies between the superomesial border of the hemisphere and the superior frontal sulcus. It is continuous with the marginal gyrus on the internal surface of

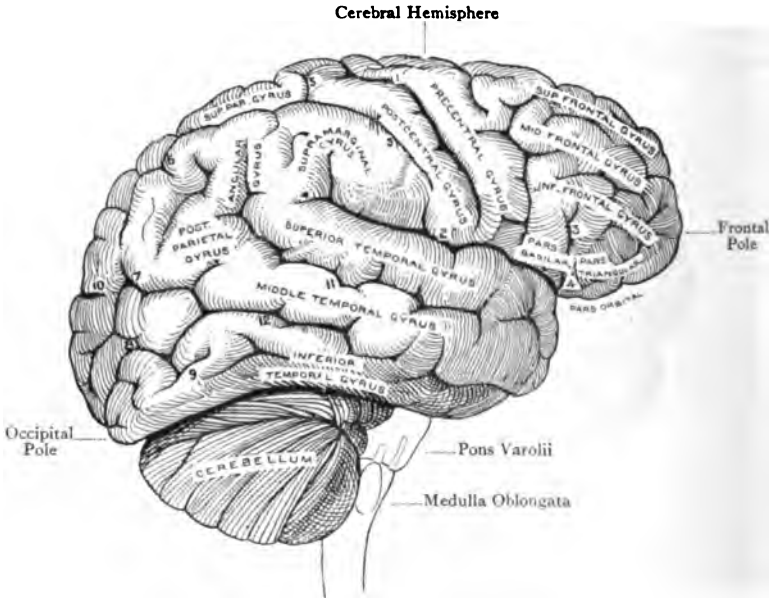

FIG. 561.—THE ENCEPHALON (RIGHT LATERAL VIEW) (HIRSCHFELD AND LEVEILLÉ).

the hemisphere, and is partially broken up into two parts, upper and lower.

The **middle frontal gyrus,** which is broad, lies between the superior and inferior frontal sulci, and is usually connected with the ascending frontal or precentral gyrus by an annectant gyrus. It is broken up anteriorly into two parts, upper and lower, by an antero-posterior secondary sulcus ; and it is cut into behind by the upper portion of the inferior part of the precentral sulcus.

The **inferior frontal gyrus** lies below the inferior frontal sulcus, and in front of the lower part of the precentral sulcus. The anterior horizontal and the ascending limbs of the fissure of Sylvius enter it and subdivide it into three parts, namely, pars orbitalis, pars

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triangularis, and pars basilaris. The *pars orbitalis* lies below the anterior horizontal limb of the fissure of Sylvius; the *pars triangularis* is situated between the anterior horizontal and the ascending limbs of the fissure of Sylvius; and the *pars basilaris* is placed between the ascending limb of the fissure of Sylvius and the lower part of the precentral sulcus. The inferior frontal gyrus is connected posteriorly with the lower end of the ascending frontal or precentral gyrus by an annectant gyrus.

The inferior frontal gyrus of the *left side* is specially important, inasmuch as the **speech-centre** is assigned to the portion of it which forms the *pars triangularis* (**le cap of Broca**).

Inferior or Orbital Surface of the Frontal Lobe.—This surface presents two sulci, olfactory and orbital.

The **olfactory sulcus** is parallel to the mesial border, from which it is separated by the gyrus rectus. It lodges the olfactory tract and olfactory bulb. The **orbital sulcus** (**triradiate sulcus** of Turner) is of very variable form, but, as a rule, bears some resemblance to the letter H. It has therefore three limbs—inner, outer, and transverse. The *inner limb* is separated from the olfactory sulcus by the internal orbital gyrus. The *outer limb* is curved, and has external to it the orbital part of the inferior frontal gyrus. The *transverse limb* passes in a more or less curved manner between the inner and outer limbs.

The **gyri** of the orbital surface are as follows: gyrus rectus, internal orbital gyrus, anterior orbital gyrus, external orbital gyrus, and posterior orbital gyrus.

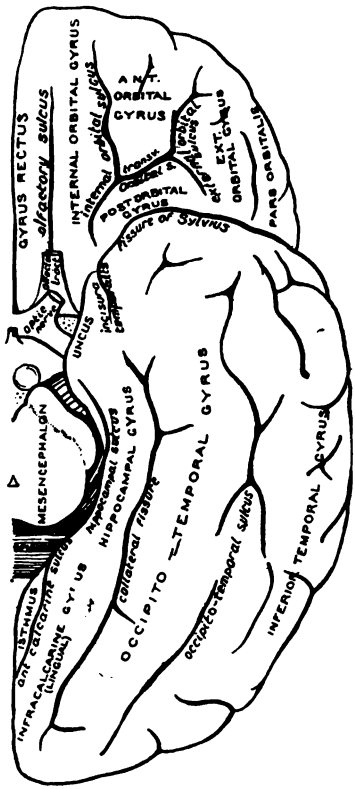

FIG. 562.—THE INFERIOR SURFACE OF THE LEFT CEREBRAL HEMISPHERE, SHOWING THE GYRI AND SULCI.

The **gyrus rectus** lies between the olfactory sulcus and the mesial border. The **internal orbital gyrus** is placed between the olfactory sulcus and the inner limb of the orbital sulcus. The **external orbital gyrus** is external to the outer limb of the orbital sulcus. The **anterior orbital gyrus** is situated in front of the transverse limb of the orbital sulcus. The **posterior orbital gyrus** lies behind the transverse limb of the orbital sulcus.

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Internal Surface of the Frontal Lobe.—The internal or mesial surface presents only one convolution, namely, the **marginal gyrus,** which is situated between the supero-mesial border of the hemisphere and the calloso-marginal sulcus. It is continuous with the superior frontal gyrus, and anteriorly is broken up by one or two sulci. Its posterior part is almost completely detached, and forms the **paracentral lobule,** which contains the upper end of the fissure of Rolando.

Parietal Lobe.—This lobe is bounded *anteriorly* by the fissure of Rolando, which separates it from the frontal lobe. *Posteriorly*

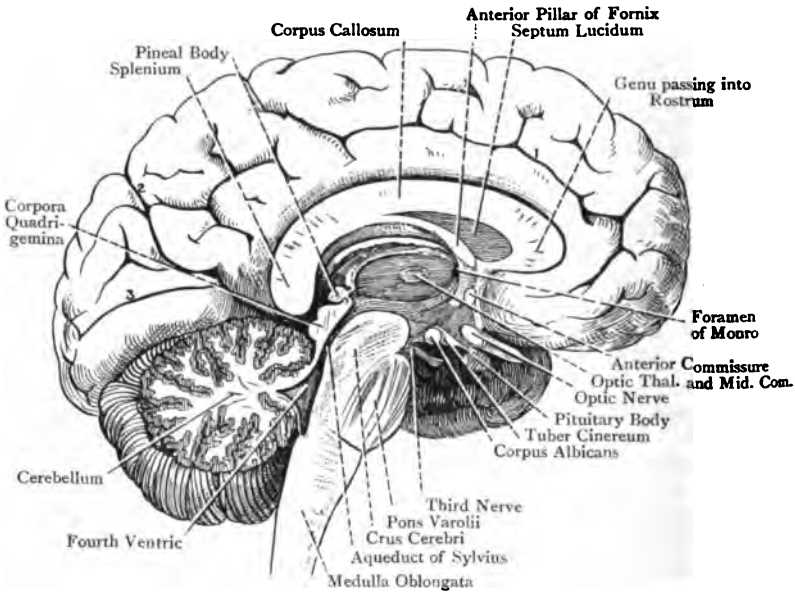

FIG. 563.—THE MESIAL SURFACE OF THE LEFT CEREBRAL HEMISPHERE (HIRSCHFELD AND LEVEILLÉ).

it is bounded by (1) the external part of the parieto-occipital fissure, which separates it from the occipital lobe; and (2) a line drawn across the external surface of the hemisphere from the extremity of this fissure towards the pre-occipital notch. Along this line the parietal and occipital lobes are continuous. *Inferiorly* the lobe is bounded by (1) the horizontal portion of the posterior limb of the fissure of Sylvius, which separates it from the temporal lobe, and (2) a line prolonging this limb backwards to meet the posterior boundary. The *pre-occipital notch* just referred to is situated on the infero-lateral border of the hemisphere, from 1½ to 2 inches in front of the occipital pole.

The parietal lobe has two surfaces, external and internal.

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External Surface.—This surface presents the following sulci: the intraparietal sulcus, composed of four parts; and the terminal portions of (*a*) the posterior limb of the fissure of Sylvius, (*b*) the first temporal or parallel sulcus, and (*c*) the second temporal sulcus.

The **intraparietal sulcus** (Turner) is composed of four parts, namely, inferior postcentral, superior postcentral, ramus horizontalis, and ramus occipitalis.

The **inferior** and **superior postcentral sulci** may be distinct, or continuous with each other. They lie behind the fissure of Rolando, with which they are parallel, and from which they are separated by the ascending parietal or postcentral gyrus.

The **ramus horizontalis** passes backwards and slightly upwards from the upper end of the inferior postcentral sulcus. It has the superior parietal gyrus above it, and the inferior parietal gyrus below it.

The **ramus occipitalis** lies behind the ramus horizontalis, with which it is usually connected. It forms the outer boundary of the gyrus which arches round the external part of the parieto-occipital fissure, namely, the *arcus parieto-occipitalis* (first annectant convolution). Posteriorly the ramus occipitalis divides into two short sulci, which diverge, one ascending, and the other descending, in the occipital lobe.

The terminal portions of (*a*) the posterior limb of the fissure of Sylvius, (*b*) the first temporal or parallel sulcus, and (*c*) the second temporal sulcus, are confined to the lower part of the external surface of the parietal lobe, where they lie in the order named, from before backwards.

The **gyri** of the external surface are as follows: ascending parietal; superior parietal; and inferior parietal, with its supramarginal, angular, and postparietal gyri.

The **ascending parietal** or **postcentral gyrus** is situated immediately behind the fissure of Rolando, which separates it from the ascending frontal or precentral gyrus in front of that fissure. Posteriorly it is limited by the superior and inferior postcentral sulci. It extends from the supero-mesial border of the hemisphere to the posterior horizontal limb of the fissure of Sylvius, and it lies parallel to the ascending frontal or precentral gyrus, with which it is connected below the fissure of Rolando.

The **superior parietal gyrus** is situated between the ramus horizontalis and the supero-mesial border of the hemisphere, where it is continuous with the quadrate lobule, or præcuneus, of the internal surface. Anteriorly it is limited by the superior postcentral sulcus, round the upper end of which it is continuous with the ascending parietal gyrus. Posteriorly it is bounded by the external part of the parieto-occipital fissure, round the extremity of which it is connected with the occipital lobe by the arcus parieto-occipitalis (first annectant convolution).

The **inferior parietal gyrus** is situated behind the inferior post-

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central sulcus, and below the ramus horizontalis and ramus occipitalis. It is broken up into three gyri, namely, supramarginal, angular, and postparietal, in this order from before backwards. The *supramarginal gyrus* arches round the ascending extremity of the posterior limb of the fissure of Sylvius. It is continuous in front with the ascending parietal gyrus below the lower end of the inferior postcentral sulcus; posteriorly with the angular gyrus; and postero-inferiorly with the first temporal gyrus. The *angular gyrus* arches round the ascending extremity of the first temporal or parallel sulcus, and is continuous with the second temporal gyrus. The *postparietal gyrus* arches round the ascending extremity of the second temporal sulcus, and is continuous with the third temporal gyrus.

Internal Surface of the Parietal Lobe.—The internal or mesial

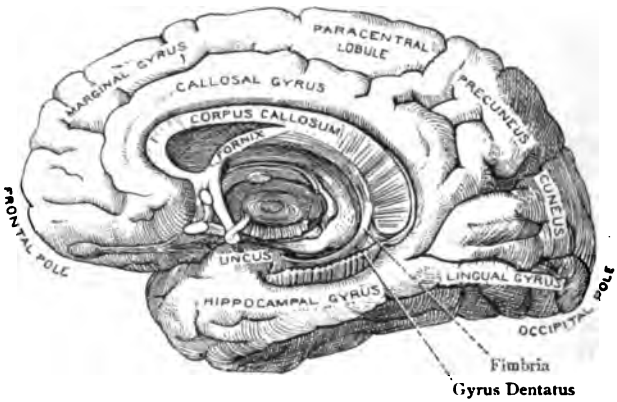

FIG. 564.—THE MESIAL SURFACE OF THE RIGHT CEREBRAL HEMISPHERE (HIRSCHFELD AND LEVEILLÉ).

surface is of quadrilateral outline, and constitutes the **quadrate lobule** or **præcuneus.** It is bounded in front by the upturned posterior extremity of the calloso-marginal sulcus, behind by the internal part of the parieto-occipital fissure, and below by the postlimbic sulcus and a portion of the limbic lobe.

Occipital Lobe.—This lobe lies behind the parietal and temporal lobes, and forms the posterior part of the cerebral hemisphere.

Externally the lobe is bounded in front by the external part of the parieto-occipital fissure, and a line connecting this fissure with the pre-occipital notch on the infero-lateral border of the hemisphere. *Internally* it is bounded in front by the internal part of the parieto-occipital fissure, which separates it from the quadrate lobule, or præcuneus, of the parietal lobe. *Inferiorly* it is continuous with the temporal and limbic lobes, but the separation may be indicated by a line connecting the pre-occipital notch with the

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portion of the limbic lobe which lies below the splenium of the corpus callosum, this portion being known as the isthmus of the limbic lobe.

The occipital lobe is pyramidal, and presents an apex and three surfaces—external, internal, and inferior.

The **apex** forms the **occipital pole** of the cerebral hemisphere.

External Surface.—This surface presents two sulci, transverse occipital and lateral occipital. The **transverse occipital sulcus** is formed by the bifurcation of the posterior end of the ramus occipitalis of the intraparietal sulcus, and it crosses the upper part of the occipital lobe transversely. Its upper limb lies a little behind the external part of the parieto-occipital fissure, from which it is separated by a portion of the arcus parieto-occipitlais; and its lower limb is behind the post-parietal gyrus. The **lateral occipital sulcus** is situated on the external surface of the occipital lobe, and extends almost horizontally from behind forwards. It divides the external surface of the lobe into two parts, upper and lower, which are connected with the parietal and temporal lobes by annectant gyri.

Internal Surface.—The internal or mesial surface presents the **calcarine fissure.** This is a deep cleft which commences on the internal aspect of the occipital pole in a bifurcated manner. It takes a curved course forwards, passing at first upwards and then downwards, and it terminates by entering the limbic lobe beneath the splenium of the corpus callosum. It is joined at a point anterior to its centre by the internal part of the parieto-occipital fissure, and between the two fissures is the *cuneus*. The calcarine fissure may be regarded as being composed of two parts, anterior, representing the portion in front of the internal part of the parieto-occipital fissure, and posterior, representing the portion behind that fissure. The *anterior calcarine fissure* gives rise to the hippocampus minor, or calcar avis, on the inner wall of the posterior cornu of the lateral ventricle.

The **gyri** of the internal surface are two in number, namely, the cuneus and the gyrus lingualis.

The **cuneus** is triangular, and is wedged in between the posterior calcarine fissure and the internal part of the parieto-occipital fissure. The **gyrus lingualis** (infracalcarine gyrus) is situated between the calcarine fissure above and the posterior part of the collateral fissure below. Anteriorly it becomes narrow, and joins the hippocampal gyrus. The lower portion of this gyrus is visible on the inferior surface of the lobe.

Inferior Surface.—The inferior or tentorial surface presents the posterior part of the occipito-temporal gyrus, internal to which is the posterior part of the collateral fissure, and internal to this again there is the lower portion of the gyrus lingualis.

Temporal Lobe.—The temporal (temporo-sphenoidal) lobe is prominent, and of large size. It is situated below the posterior horizontal limb of the fissure of Sylvius, and behind the stem of that fissure. Superiorly it is bounded by (1) the horizontal portion

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of the posterior limb of the fissure of Sylvius, and (2) a line prolonging this limb backwards to meet the posterior boundary of the parietal lobe. Anteriorly it is bounded by the stem of the fissure of Sylvius, which separates it from the orbital area of the frontal lobe. Posteriorly it is continuous with the occipital lobe, but the separation may be indicated by the following lines: externally by a line connecting the extremity of the external part of the parieto-occipital fissure with the pre-occipital notch, and inferiorly by a line connecting the pre-occipital notch with the portion of the limbic lobe which lies below the splenium of the corpus callosum (isthmus of the limbic lobe). Inferiorly it is separated from the hippocampal gyrus by the collateral fissure. The temporal lobe is somewhat pyramidal, the rounded apex being directed forwards. The apical part forms the **temporal pole,** and it overhangs from behind the stem of the fissure of Sylvius. The uncus of the hippocampal gyrus lies on its inner side, but on a more posterior level, and separated from it by the temporal sulcus.

The lobe presents three surfaces—superior, external, and inferior.

The **superior** or **opercular surface** is concealed within the fissure of Sylvius, and is directed towards the island of Reil.

The **external surface** presents two horizontal sulci and three convolutions, the latter being disposed in horizontal tiers.

The **sulci** are called first temporal and second temporal, respectively. The **first temporal sulcus** is parallel to the posterior limb of the fissure of Sylvius, from which circumstance it is called the parallel sulcus. It commences near the temporal pole, and posteriorly it turns upwards into the parietal lobe, where the angular gyrus arches round it. The **second temporal sulcus** is parallel to the first, below which it lies, and it is usually broken up into two or more parts by annectant gyri. Posteriorly it turns upwards into the parietal lobe, where the postparietal gyrus curves round it.

The **gyri** of the external surface, as stated, are arranged in horizontal tiers, and are three in number, first, second, and third, in this order from above downwards.

The **first temporal gyrus** is situated between the posterior limb of the fissure of Sylvius and the parallel sulcus. Posteriorly it is continuous with the supramarginal, and slightly with the angular, gyri of the parietal lobe. The **second temporal gyrus** lies between the parallel and second temporal sulci, and posteriorly is continuous with the angular and postparietal gyri of the parietal lobe. The **third temporal gyrus** lies below the second temporal sulcus, and posteriorly is continuous with the lower part of the external surface of the occipital lobe.

The **inferior** or **tentorial surface** of the temporal lobe presents the occipito-temporal sulcus and the occipito-temporal gyrus. The **occipito-temporal sulcus** extends from before backwards, lying near the infero-lateral margin of the hemisphere, and external to the collateral fissure. It is usually broken up into parts by annectant

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convolutions. The **occipito-temporal gyrus** is situated between the occipito-temporal sulcus and the collateral fissure, and extends from the occipital pole to the temporal pole. External to the occipito-temporal sulcus there is the narrow inferior or tentorial surface of the third temporal gyrus.

Island of Reil, Central Lobe, or Insula.—This lobe is situated deeply within the fissure of Sylvius, and is concealed from view by the opercular gyri, to be presently described. It is triangular, the apex being directed downwards towards the vallecula Sylvii and locus perforatus anticus. The circular or limiting sulcus being here absent, the grey matter of the apex is continuous with that of the locus perforatus anticus, this point being called the *limen insulæ*. Elsewhere the island of Reil is surrounded by the circular or limiting sulcus, which has been already described. The insula presents several sulci, which diverge as they pass from the apical region to the base, and these map it out into gyri. One of these sulci is known as the **sulcus centralis insulæ.** It extends from the apex to the base in an upward and backward direction, almost in line with the fissure of Rolando, and it divides the insula into two lobules, precentral and postcentral.

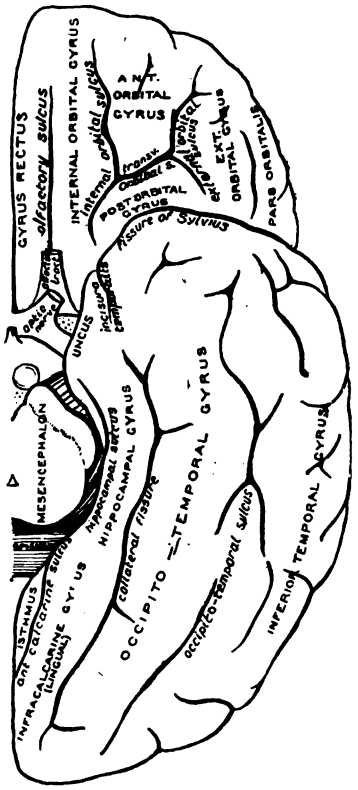

FIG. 565.—THE INFERIOR SURFACE OF THE LEFT CEREBRAL HEMISPHERE, SHOWING THE GYRI AND SULCI.

The **precentral lobule** is composed of three short gyri, called the *gyri breves*, which converge as they descend from the base, but they do not reach the apex or **pole** of the precentral lobule. The **postcentral lobule** is formed by the *gyrus longus*, which is usually broken up into two gyri towards the base of the insula.

The direct internal or mesial relation of the insula is the claustrum, internal to which there are, in succession, the external capsule, the nucleus lenticularis, the internal capsule, and the nucleus caudatus.

The insula and the corpus striatum represent the **stem** of the cerebral hemisphere, whilst the remainder of the hemisphere is known as the **pallium** or **mantle.**

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Opercula Insulæ.—The parts of the cerebral hemisphere which bound the three limbs of the fissure of Sylvius and overhang the insula are called the **opercula insulæ.** They are four in number, namely, fronto-parietal, temporal, frontal, and orbital.

The **fronto-parietal operculum** forms the upper lip, and the **temporal operculum** forms the lower lip, of the posterior limb of the fissure of Sylvius. The **frontal operculum** represents the *pars triangularis* of the inferior frontal gyrus—that is to say, the part which lies between the ascending and the anterior limbs of the fissure of Sylvius. The **orbital operculum** represents the *pars orbitalis* of the inferior frontal gyrus, and lies below the anterior limb of the fissure of Sylvius.

Limbic Lobe.—This lobe is situated on the internal or mesial surface of the cerebral hemisphere. It is composed of two convo-

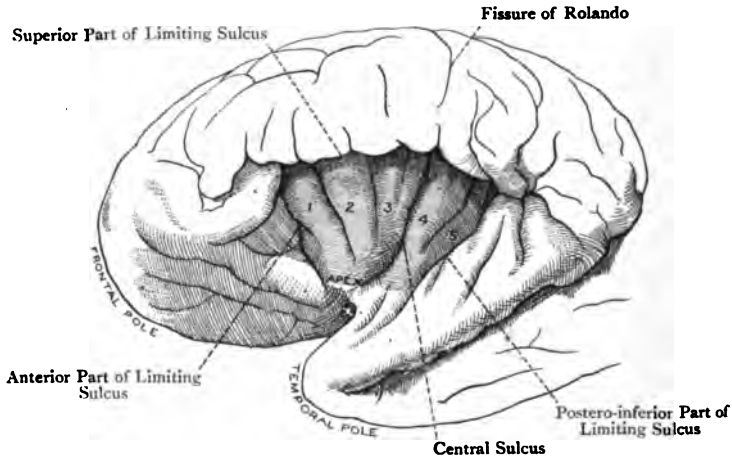

FIG. 566.—THE LEFT ISLAND OF REIL (POIRIER, FROM EBERSTALLER).

1, 2, 3, Gyri Breves; 4, 5, Gyri Longi; ×, Limen Insulæ.

lutions, namely, the callosal gyrus, or gyrus fornicatus, and the hippocampal gyrus, so disposed as to form an almost complete ring round the corpus callosum and subjacent parts. The open part of the ring, which is very small, is situated at the locus perforatus anticus, and is occupied by the roots of the olfactory tract. Around its circumference the limbic lobe is bounded superiorly by the calloso-marginal fissure, posteriorly by the postlimbic sulcus, and inferiorly by the anterior part of the collateral fissure and the *incisura temporalis*. The callosal and hippocampal gyri become continuous beneath the splenium of the corpus callosum, the connecting portion, which is narrow, being known as the *isthmus of the limbic lobe.*

The **callosal gyrus** is intimately related to the corpus callosum, round which it arches: hence the name **gyrus fornicatus.** It com-

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mences at the locus perforatus anticus, below the rostrum of the corpus callosum, and it terminates below the splenium of that body. Between these two points it pursues a sweeping course, passing forwards beneath the rostrum, upwards in front of the genu, backwards above the body of the corpus callosum, and finally curving round the splenium, to be continued into the hippocampal gyrus through the *isthmus*. It is bounded superiorly by the calloso-marginal fissure, which separates it from the marginal gyrus and paracentral lobule, and, posterior to the latter, it is partially separated from the præcuneus by the postlimbic sulcus. The callosal gyrus is separated from the corpus callosum by the **callosal sulcus.**

The **hippocampal gyrus** extends from a point below the splenium of the corpus callosum to the locus perforatus anticus. Posteriorly it is continuous with the callosal gyrus through the *isthmus*, and anteriorly it is connected with the outer root of the olfactory tract, the inner root of that tract being connected with the anterior part of the callosal gyrus. It forms the lower part of the limbic lobe, and does not extend quite so far forwards as the temporal pole. In this region it is bent backwards upon itself, and this recurrent anterior portion is called the **uncus.**

The hippocampal gyrus is bounded externally by the anterior part of the collateral fissure and the *incisura temporalis*, which latter separates the uncus from the adjacent portion of the temporal lobe. Internally it is bounded by the hippocampal or dentate fissure. Posteriorly the calcarine fissure enters it, and divides it into two parts, upper and lower. The upper part is the *isthmus*, which connects it with the callosal gyrus, and the lower part is continuous with the gyrus lingualis.

Cingulum.—The cingulum is a tract of *long association fibres*, which is connected with the limbic lobe. It commences near the locus perforatus anticus and is closely related to the callosal and hippocampal gyri, lying upon the inferior surface of the former and the superior surface of the latter. The fibres of the cingulum are regarded as connecting the gyri of the limbic lobe with the cortex of the cerebral hemisphere.

Hippocampal or Dentate Fissure.—This fissure commences behind the splenium of the corpus callosum, where it is continuous with the callosal sulcus. It is directed forwards, lying between the gyrus dentatus above and the hippocampal gyrus below, and it terminates within the uncus of the hippocampal gyrus.

The hippocampal or dentate fissure, being complete, gives rise to the elevation in the descending cornu of the lateral ventricle, called the hippocampus major.

Gyrus Dentatus (*Fascia Dentata* of Tarinus).—The gyrus dentatus is situated above the hippocampal gyrus, and below the fimbria. It is separated from the hippocampal gyrus by the hippocampal fissure, and from the fimbria by a slight groove, called the *fimbrio-dentate sulcus*. The dentate gyrus is narrow, and its free margin

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is indented or notched: hence the name *dentatus*. It commences behind the splenium of the corpus callosum, and is directed forwards above the hippocampal gyrus into the curve of the uncus. Here it describes a bend, after which it emerges from the curve of the uncus, and, crossing the recurved part, is lost on its outer aspect. This portion of the dentate gyrus is called the *frenulum Giacomini*.

Posteriorly it is continuous round the splenium with the rudimentary *gyrus supracallosus*, which contains the *mesial* and *lateral longitudinal striæ* of one half of the upper surface of the corpus callosum.

Fimbria.—The fimbria is the prolongation of the posterior pillar of the fornix. It is situated above the gyrus dentatus, from which it is separated by the fimbrio-dentate sulcus. Posteriorly it turns upwards round the posterior extremity of the optic thalamus, and so becomes continuous with the posterior pillar of the fornix. Anteriorly it enters the uncus.

Development of the Cerebral Hemispheres.—Each hemisphere is developed from the wall of the **cerebral vesicle**, which is a hollow protrusion from the upper and lateral part of the telencephalon, one of the divisions of the prosencephalon. The anterior wall of that portion of the telencephalon which lies between the two cerebral vesicles is called the **lamina terminalis.**

The hemispheres grow out of proportion to the other parts of the encephalon in a forward, upward, and backward direction. Their backward growth is so great that they completely cover the other parts of the encephalon by the seventh month of intra-uterine life.

The sulci and gyri of the hemispheres first appear about the fifth month of intra-uterine life.

Development of the Insula and **Fissure of Sylvius.**—The insula, or island of Reil, appears as a depression, called the **Sylvian fossa**, on the lateral aspect of the cerebral vesicle. The wall of this fossa becomes developed into the *opercula insulæ*, and, as these grow, they cover the insula, and give rise to the limbs of the fissure of Sylvius.

Olfactory Lobe.

The olfactory lobe is rudimentary in man. It is composed of two lobules, anterior and posterior (His).

Anterior Lobule.—This consists of the following parts: (1) the olfactory bulb; (2) the olfactory tract, with its two roots, mesial and lateral; (3) the trigonum olfactorium; and (4) the area of Broca.

The **olfactory bulb** is the enlarged anterior extremity of the olfactory tract. It is oval, and its upper surface is in contact with the orbital surface of the frontal lobe, whilst its lower surface rests upon one half of the cribriform plate of the ethmoid bone. The lower surface receives the olfactory nerves, which arise from the olfactory cells of the olfactory mucous membrane and pass through the foramina of the cribriform plate.

The **olfactory tract** is a white band which extends backwards from the olfactory bulb, both of them occupying the olfactory sulcus on the inner part of the orbital surface of the frontal lobe. Posteriorly it divides into two roots, inner and outer, which diverge and enclose between them the trigonum olfactorium.

The **inner** or **mesial root** passes inwards, in a curved manner,

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behind the area of Broca. Some of its fibres pass into this area, and others enter the anterior extremity of the callosal gyrus, or gyrus fornicatus.

The **outer** or **lateral root** passes backwards and outwards over the outer part of the posterior lobule (locus perforatus anticus), and enters the anterior part of the hippocampal gyrus.

The **trigonum olfactorium** is the area of grey matter which lies

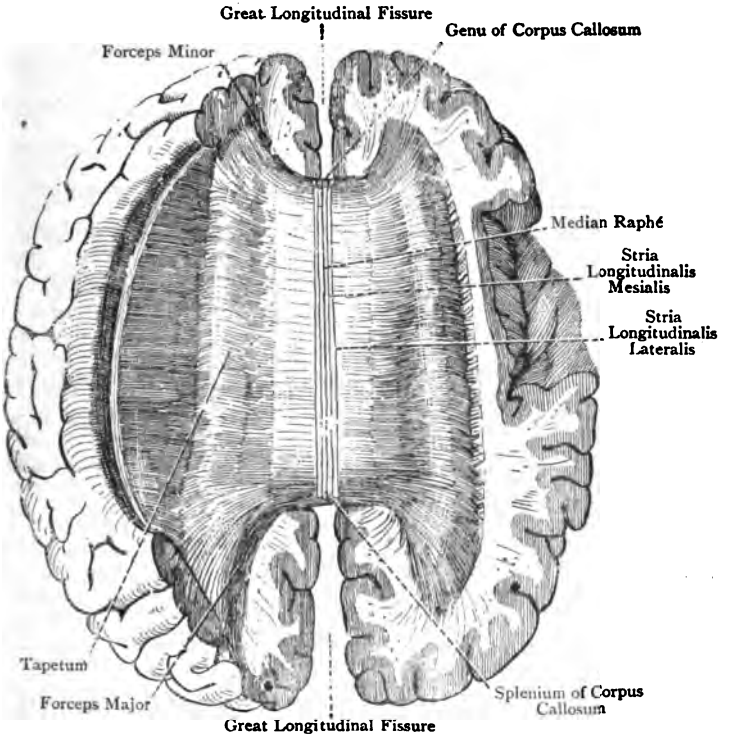

FIG. 567.—THE CORPUS CALLOSUM (SUPERIOR VIEW) (HIRSCHFELD AND LEVEILLÉ).

between the diverging mesial and lateral roots of the olfactory tract. It is sometimes described as the *middle* or *grey root* of the olfactory tract.

The **area of Broca** is situated in front of the inner root of the olfactory tract. It is continuous with the commencement of the callosal gyrus.

Posterior Lobule.—This represents the *locus perforatus anticus.* Anteriorly it is separated from the anterior lobule by the *fissura prima* of His; externally it is prolonged into the vallecula Sylvii;

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and internally it is limited by the peduncle of the corpus callosum.

Development.—The olfactory lobe is developed as a hollow protrusion from the antero-inferior part of the cerebral vesicle. This protrusion becomes solid, and gives rise to the olfactory tract and olfactory bulb.

Rhinencephalon.—The rhinencephalon consists of the *olfactory lobe, uncus, gyrus dentatus, supracallosal* and *subcallosal gyri, half of the septum lucidum, half of the fornix*, and *hippocampus major*.

Corpus Callosum.—The corpus callosum connects the two cerebral hemispheres. It is situated at the bottom of the great longitudinal fissure, and extends nearer to the front than back of the hemispheres.

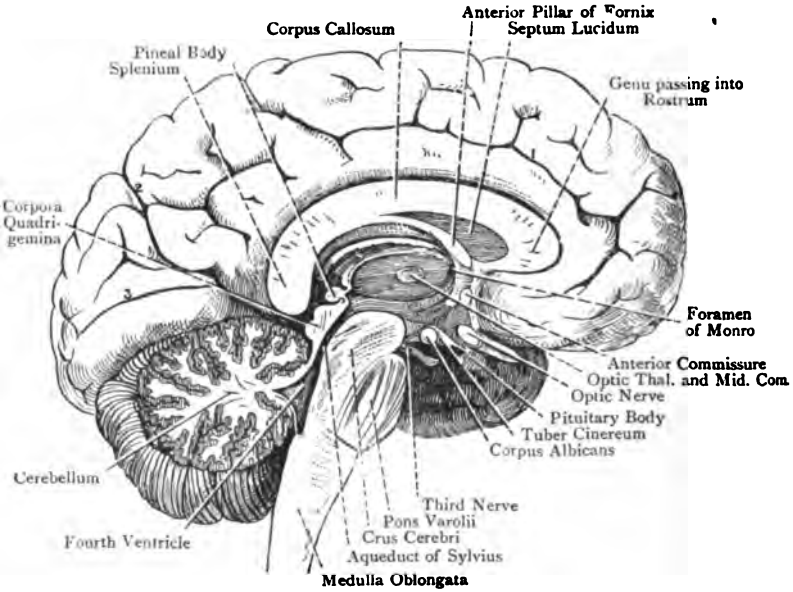

FIG. 568.—THE MESIAL SURFACE OF THE LEFT CEREBRAL HEMISPHERE (HIRSCHFELD AND LEVEILLÉ).

It is thicker in front and behind than at the centre, and it attains its greatest thickness *posteriorly*, where more fibres cross in it than elsewhere, on account of there being more of the hemisphere behind it than in front of it.

The **superior surface** is related to the falx cerebri, but is in contact with it only posteriorly. It is covered by a thin layer of grey matter, and presents a transversely-striated appearance, indicative of the direction of its fibres. In the median line there is a slight antero-posterior furrow or **raphé**, and on either side of this there is a white longitudinal band, called the **stria longitudinalis mesialis.** The two striæ longitudinales mesiales, right and left, are sometimes

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spoken of as the *nerves of Lancisi*. External to each mesial stria, and situated under cover of the gyrus fornicatus or callosal gyrus, there is another band, composed of grey matter, called the **stria longitudinalis lateralis.** Each lateral stria is sometimes spoken of as the *tænia tecta* ('covered tænia'), from the circumstance that it is covered by the callosal gyrus.

The striæ of each side may be traced posteriorly round the splenium into the corresponding gyrus dentatus. Anteriorly each mesial stria, along with the grey matter in which it lies, passes round the genu and backwards on the under surface of the rostrum, under the name of the **geniculate gyrus.** This enters the subcallosal gyrus, and finally passes to the temporal pole.

The mesial and lateral longitudinal striæ of each side, together with the thin layer of gray matter, represent a rudimentary convolution called the **supracallosal gyrus.**

The **posterior extremity** of the corpus callosum is called the **splenium.** It is very thick, which is due, as stated, to the great number of fibres which cross in it, on account of there being more of the hemisphere behind it than in front of it. The splenium is rolled upon itself, so that its lower part is directed forwards. It lies over the mesencephalon.

Anteriorly the corpus callosum is bent upon itself, and passes at first downwards and then backwards. The bent portion is called the **genu,** and the portion which passes backwards is termed the **rostrum.** The rostrum terminates in the median line by becoming connected with the lamina cinerea, and on either side it passes into the **peduncles** of the corpus callosum, otherwise known as the **subcallosal gyri.** Each subcallosal gyrus, with the contained stria longitudinalis mesialis, now called, as stated, the geniculate gyrus, passes downwards on the internal surface of the cerebral hemisphere to the locus perforatus anticus, lying in front of the lateral portion of the lamina cinerea. The geniculate gyrus then passes backwards and outwards along the posterior margin of the locus perforatus anticus, and so reaches the temporal pole.

The **inferior surface** of the corpus callosum is divisible into a mesial and two lateral portions. The *mesial portion* is connected posteriorly with the fornix, and over the remainder of its extent with the septum lucidum. Each *lateral portion* enters into the roof of the body and anterior cornu of the corresponding lateral ventricle.

Destination of the Callosal Fibres.—The transverse fibres of the corpus callosum, on entering the white medullary substance of each cerebral hemisphere, traverse it in a radiating manner as they pass to the cerebral cortex. They constitute the **radiatio corporis callosi,** and intersect in their course the fibres which pass between the internal capsule and the cerebral cortex, which form the *corona radiata*. The fibres from the central portion or body and upper part of the splenium of the corpus callosum constitute the *tapetum*. This forms the roof of the body of the lateral ventricle,

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the chief part of the roof and the outer wall of the commencement of the middle or descending cornu, and the roof and outer wall of the posterior cornu. The fibres of the tapetum ultimately pass into the temporal and occipital lobes. The fibres from the region of the genu curve forwards into the front part of the frontal lobe, and form the roof of the anterior cornu of the lateral ventricle. They constitute the *forceps minor*. The fibres from the lower part of the splenium curve backwards into the occipital lobe, and give rise to an eminence on the inner wall of the posterior cornu of the lateral ventricle. They constitute the *forceps major*.

Development.—The corpus callosum may be regarded as being developed from the **lamina terminalis.**

Fornix.—This is an arched lamina of white longitudinal fibres, which lies beneath the corpus callosum, with which it is connected posteriorly, but from which it is separated anteriorly by the septum lucidum. It is composed of two lateral halves, which are united together in the median line to form the body of the fornix; but in front and behind they are separated from each other, and form the anterior and posterior pillars. The fornix is thus composed of a body, two anterior pillars, and two posterior pillars.

The **body** is triangular, being narrow in front, where it is continuous with the anterior pillars, and broad behind, where it is prolonged into the posterior pillars. The *superior surface* of the body is connected posteriorly with the corpus callosum, and anteriorly with the septum lucidum. Each *lateral border* is well defined, and projects slightly into the lateral ventricle. The *inferior surface* rests directly upon the velum interpositum, beneath which, in the median line, is the third ventricle, and on either side the upper surface of the optic thalamus.

The **anterior pillars** are two round bundles, which are continuous with the anterior part of the body, and are slightly separated from each other. They pass downwards in front of the foramina of Monro, traversing the grey matter on the sides of the third ventricle. On reaching the base of the brain each pillar becomes twisted in the form of a loop, and forms the white portion of the corresponding corpus albicans or mammillare. The fibres of the anterior pillar terminate in the grey nucleus of the corpus albicans, and from this nucleus a bundle of fibres, called the bundle of **Vicq d'Azyr,** passes upwards and backwards into the optic thalamus.

The anterior commissure lies in front of the anterior pillars.

The **posterior pillars** are prolongations of the posterior part of the body on either side. They are flattened bands, which at first adhere to the under surface of the corpus callosum. Subsequently however, each curves outwards and downwards round the posterior extremity of the optic thalamus, and enters the descending cornu of the lateral ventricle. Here the posterior pillar comes into contact with the hippocampus major, upon the surface of which some of its fibres become spread out, forming the *alveus*. The rest of the

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fibres are prolonged as a narrow band of white matter, called the **fimbria,** or **tænia hippocampi,** along the inner concave border of the hippocampus major, to which it is attached, as far as the uncus. As the two posterior pillars diverge from each other they enclose between them a small triangular space on the under surface of the corpus callosum posteriorly. This space is crossed by transverse fibres, and is known as the *lyra* or *psalterium,* from its supposed resemblance to a lyre. The transverse fibres form a commissure between the two hippocampi majores, and the lyra is therefore known as the **hippocampal commissure.** Each lateral half of the fornix is to be regarded as establishing a communication between the hippocampus major, in which the majority of its fibres originate, and the optic thalamus of the same side through means of (1) the anterior pillar, (2) the corpus albicans, and (3) the bundle of Vicq d'Azyr.

Development.—The fornix may be regarded as being developed from the **lamina terminalis.**

Anterior Commissure.—This is a round bundle of white fibres which crosses the middle line immediately in front of the anterior pillars of the fornix. Anteriorly its central portion is connected with the lamina cinerea, and posteriorly the central portion appears between the anterior pillars of the fornix, where it forms part of the anterior boundary of the third ventricle, and is covered by the ventricular ependyma. On either side the commissure enters the cerebral hemisphere, and divides into two parts, olfactory and temporal. The *olfactory portion* is of small size, and enters the corresponding olfactory tract. Some of its fibres serve to connect the olfactory bulb of one side with that of the other side. The other fibres connect the olfactory bulb of one side with the temporal lobe of the opposite side. The *temporal portion* is of large size, and its fibres disappear in the white matter of the temporal lobe.

The anterior commissure serves to connect the olfactory bulbs and the temporal lobes.

Septum Lucidum.—This is a thin vertical partition which is situated between the anterior cornua of the lateral ventricles, as well as between the front parts of the bodies of these ventricles. It is triangular, being broad in front and narrow behind. Posteriorly it is attached above to the under surface of the corpus callosum, and below to the upper surface of the body of the fornix. Anteriorly it occupies the concavity behind the genu of the corpus callosum, being attached above to the corpus callosum and below to the rostrum of that body. The septum lucidum is composed of two delicate laminæ. The outer surface of each lamina looks into the corresponding lateral ventricle, and is covered by the ventricular ependyma (epithelium). The inner surface faces that of its fellow, a narrow interval, representing the fifth ventricle, intervening between the two. Each lamina consists of white

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matter, which is covered by grey matter on the surface looking towards the fifth ventricle.

The two laminæ are formed from portions of the mesial walls of the two cerebral hemispheres which have become detached in the course of the development of the corpus callosum and fornix.

Fifth Ventricle.—The fifth ventricle, or **ventricle of the septum,** is the narrow cleft-like interval between the two laminæ of the septum lucidum. It is a closed space, and has therefore no communication with the other ventricles. It is destitute of any ependymal lining, and contains a very little fluid.

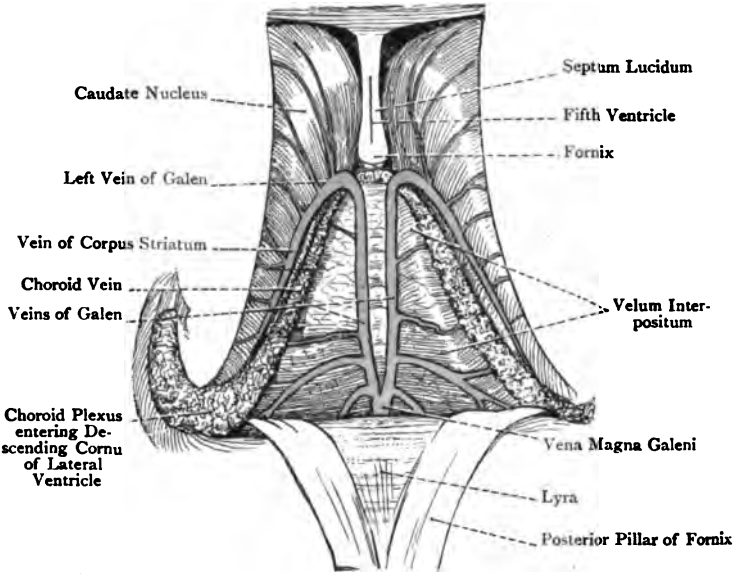

FIG. 569.—THE VELUM INTERPOSITUM AND VEINS OF GALEN.

As regards **development,** it differs from the other ventricles, having been originally a part of the great longitudinal fissure.

Velum Interpositum.—This is also known as the *tela choroidea superior*, in contradistinction to the *tela choroidea inferior*, which is the pia mater forming the roof of the lower part of the fourth ventricle. It lies immediately beneath the fornix, and rests upon the ependymal roof of the third ventricle, and also upon the adjacent portions of the optic thalami. It consists of two layers of pia mater, and is triangular, the apex being situated behind the anterior pillars of the fornix at the foramina of Monro and the base lying beneath the splenium of the corpus callosum. In the latter situation the two layers of the velum interpositum become

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continuous with the pia mater, which has entered through the **transverse fissure,** situated between the splenium of the corpus callosum and the corpora quadrigemina. On either side the velum interpositum projects beyond the lateral border of the fornix, and appears as a vascular fringe in the lateral ventricle, where it is covered by the ventricular ependyma. This fringe is known as the **choroid plexus of the lateral ventricle.** Posteriorly it is prolonged into the descending cornu. Anteriorly it approaches its fellow of the opposite side, and the two unite in the median line behind the foramina of Monro. From this junction two other choroid plexuses extend backwards on the inferior surface of the velum interpositum, one on either side of the median line. They form the **choroid plexuses of the third ventricle,** and lie superficial to the ependymal roof of that cavity.

The principal veins in connection with the velum interpositum are the two choroid veins and the two veins of Galen. The **choroid vein** of each side is situated in the choroid plexus of the lateral ventricle. It passes forwards and inwards to a point behind the corresponding foramen of Monro, where it joins the **vein of the corpus striatum,** which lies between the optic thalamus and the corpus striatum. In this manner the vein of Galen of one side is formed.

The **veins of Galen** are two in number, right and left. Each vein is formed, as just stated, by the union between the choroid vein and the vein of the corpus striatum behind the corresponding foramen of Monro. The two veins of Galen pass backwards within the velum interpositum, one on either side of the median line. At first they are near each other; then they diverge; but subsequently they again come together and unite to form one vessel, called the **vena magna Galeni,** which opens into the anterior extremity of the straight sinus. Each vein of Galen receives numerous tributaries from the corresponding choroid plexus of the third ventricle, optic thalamus, corpus callosum, corpora quadrigemina, and pineal body. Near its termination it is joined by the large **basilar vein,** which is formed at the locus perforatus anticus by the union of the **anterior cerebral vein** with the **deep Sylvian vein.** The vena magna Galeni receives tributaries from the upper surface of the cerebellum and from the occipital lobes of the cerebral hemispheres.

Lateral Ventricles.

The lateral ventricles are the ventricles of the cerebral hemispheres, and are two in number, right and left. They are of irregular shape, and each occupies about two-thirds of the length of the corresponding hemisphere. They are lined with ependyma (epithelium), and contain a certain amount of cerebro-spinal fluid. Each ventricle communicates with the third ventricle by the foramen of Monro of its own side, which is situated between the

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anterior pillar of the fornix and the front part of the optic thalamus. The lateral ventricle of either side consists of a body and three cornua—anterior, middle or descending, and posterior.

The **body** extends from the foramen of Monro to the level of the splenium of the corpus callosum. The **anterior cornu** is situated in front of the foramen of Monro, and curves forwards and outwards into the frontal lobe. The **middle** or **descending cornu**

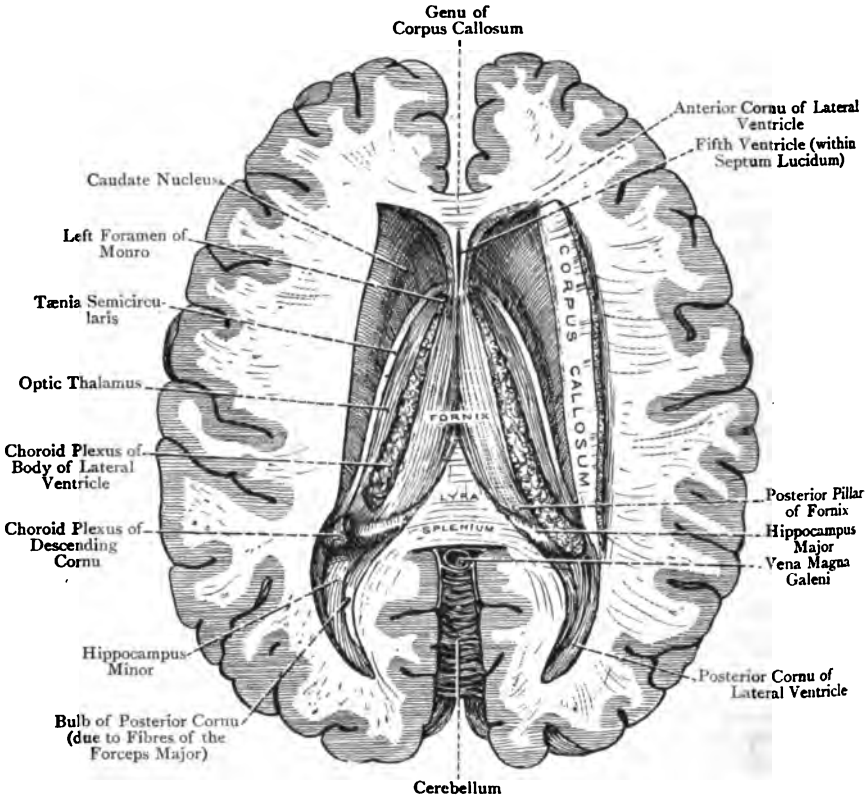

FIG. 570.—THE LATERAL VENTRICLES OF THE CEREBRUM (AFTER HIRSCHFELD AND LEVEILLÉ).

enters the temporal lobe, and describes a remarkable curve as it sweeps round the posterior extremity of the optic thalamus. Its direction is *backwards*, *outwards*, *downwards*, *forwards*, and finally *inwards* to a point about 1 inch from the temporal pole. The **posterior cornu** curves backwards and inwards into the occipital lobe.

The **body** of the lateral ventricle presents a roof, an inner wall,

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and a floor. The **roof** is formed by the corpus callosum (tapetum). The **inner wall** is formed by the posterior part of the septum lucidum, and, behind this, by the attachment of the body of the fornix to the under surface of the corpus callosum. *Externally* the body is limited by the meeting of the roof and floor. The **floor** presents the following structures, in order from within outwards: (1) the sharp lateral border of the fornix; (2) the choroid plexus of the lateral ventricle; (3) a portion of the upper surface of the optic thalamus; (4) an oblique groove, extending forwards and inwards

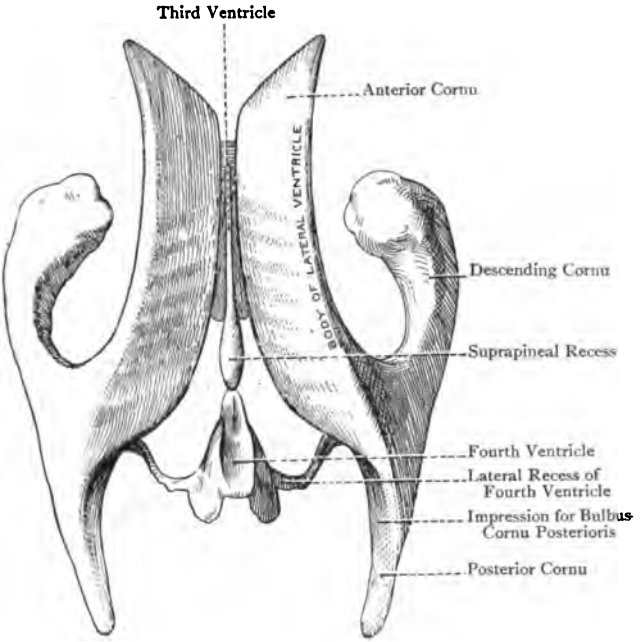

FIG. 571.—DRAWING OF A METAL CAST OF THE VENTRICLES OF THE BRAIN OF AN ADULT (SUPERIOR VIEW) (RETZIUS).

between the optic thalamus and nucleus caudatus, in which there are (*a*) a white band, called the **tænia semicircularis,** and (*b*) the vein of the corpus striatum, the latter being the more superficial of the two; and (5) the narrow part of the nucleus caudatus of the corpus striatum.

The **anterior cornu** has its **roof** formed by the corpus callosum (forceps minor). *Externally* it is limited by the meeting of the roof and floor. *Anteriorly* where it is pointed, it is bounded by part of the posterior aspect of the genu of the corpus callosum. Its **inner wall** is formed by the anterior part of the septum lucidum.

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The **floor** presents a prominent swelling, which is the large round extremity of the nucleus caudatus of the corpus striatum.

The **posterior cornu** has its **roof** and **outer wall** formed by the tapetum of the corpus callosum. The **inner wall** presents two elongated, curved eminences, upper and lower. The *upper* eminence is produced by the fibres of the forceps major as they sweep backwards from the lower part of the splenium of the corpus callosum to the occipital lobe. It is called the **bulb of the posterior cornu.** The *lower* eminence is called the **calcar avis** or **hippocampus minor,**

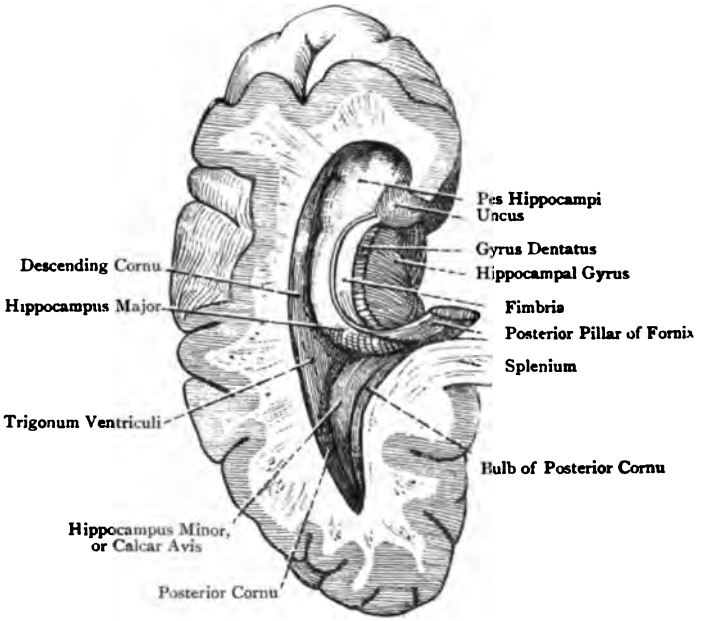

FIG. 572.—THE DESCENDING AND POSTERIOR CORNUA OF THE LEFT LATERAL VENTRICLE (AFTER HIRSCHFELD AND LEVEILLÉ).

(The Descending Cornu has been laid open throughout its entire extent).

and is produced by the anterior calcarine fissure on the mesial surface of the cerebral hemisphere.

The **middle** or **descending cornu** is situated in the temporal lobe. Its **roof** is formed chiefly by the tapetum of the corpus callosum, and, at the deep end of the cornu, presents the **amygdaloid tubercle,** which is produced by a collection of grey matter, called the **amygdaloid nucleus.** The narrow part or tail of the nucleus caudatus and the tænia semicircularis are prolonged into the roof, and extend in it as far as the amygdaloid nucleus. The **floor** of the descending cornu presents the following structures: (1) the hippocampus major, or cornu Ammonis; (2) the fimbria or tænia hippo-

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campi; (3) the eminentia collateralis, or pes accessorius; and (4) the choroid plexus of the descending cornu. The **hippocampus major,** or **cornu Ammonis,** is a prominent curved elevation which traverses the entire length of the descending cornu, accurately adapting itself to its curves. It enlarges as it descends, and beneath the amygdaloid tubercle it terminates in a swelling, which is notched on the surface. This swelling is called the **pes hippocampi.**

The hippocampus major is produced by the dentate or hippocampal fissure on the mesial surface of the cerebral hemisphere.

The **fimbria,** or **tænia hippocampi,** is the continuation of the posterior pillar of the fornix. It lies along the inner concave border of the hippocampus major, to which it is attached, and it is composed of white fibres, some of which form the layer on the surface of the hippocampus major, called the *alveus*.

The **eminentia collateralis,** or **pes accessorius,** is an elevation which is situated in the angle between the descending and posterior cornua, where there is a small triangular space, called the *trigonum ventriculi*. It extends backwards into the posterior cornu, and for a variable distance into the descending cornu.

The eminentia collateralis is produced by the central portion of the collateral fissure on the tentorial surface of the cerebral hemisphere.

The **choroid plexus of the descending cornu** rests upon the surface of the hippocampus major, and is continuous with that of the body of the lateral ventricle. It is covered by the ependyma of the inner wall of the descending cornu, which it invaginates. When the choroid plexus is removed its ependymal covering comes away along with it, and the choroidal fissure then becomes apparent.

The **choroidal fissure** is situated between the fimbria and the roof of the descending cornu, and, curving round the back part of the optic thalamus, it is traceable as far forwards as the foramen of Monro of the same side. In the other direction it extends to the lower extremity of the descending cornu. It is produced by an invagination of the ventricular ependyma, which invests the choroid plexus. In the undisturbed state the fissure is occupied by the choroid plexus, covered by ependyma. By means of the choroidal fissure the ventricular cavity communicates with the mesial surface of the cerebral hemisphere.

Development.—The **lateral ventricles** represent the cavities of the primitive cerebral vesicles. The **choroidal fissure** is developed as an invagination of the mesial wall of the cerebral vesicle; and the choroid plexus is developed from a growth of mesoblast into the choroidal fissure.

Basal Ganglia of the Cerebral Hemispheres.

The basal ganglia of each cerebral hemisphere are as follows: the nucleus caudatus and nucleus lenticularis of the corpus striatum, the claustrum, and the amygdaloid nucleus.

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The **corpus striatum** is a large ovoid mass, which is situated in front, and on the outer side, of the optic thalamus. It is composed of two collections of grey matter, one of which is intraventricular and the other extraventricular. The *intraventricular portion* is called

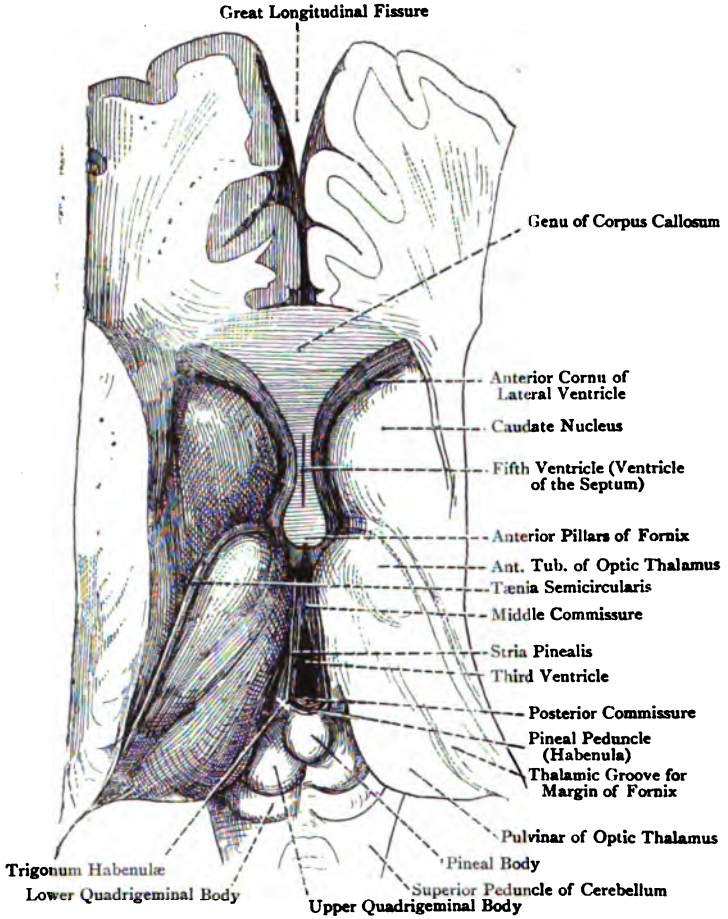

FIG. 573.—THE THIRD VENTRICLE, PORTIONS OF THE LATERAL VENTRICLES, PINEAL BODY, AND CORPORA QUADRIGEMINA (SUPERIOR VIEW) (HENLE).

(The Corpus Callosum, Fornix, and Velum Interpositum have been removed).

the **nucleus caudatus.** The *extraventricular portion* is embedded in the white matter of the cerebral hemisphere, and is termed the **nucleus lenticularis.** Between these two nuclei there is a part of the thick tract of white fibres which constitutes the **internal cap-**

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sule; and on the outer side of the nucleus lenticularis there is the thin lamina of white matter, called the **external capsule.** When a coronal section is made through the corpus striatum on a level with the anterior part of the nucleus lenticularis, the white matter of the front part of the internal capsule is seen to be intersected by striæ of grey matter which pass between the nucleus caudatus and nucleus lenticularis. From the striped appearance thus produced the body has received the name of *corpus striatum.*

The **nucleus caudatus** is pyriform. The large round end is directed forwards, and projects into the anterior cornu of the lateral ventricle.

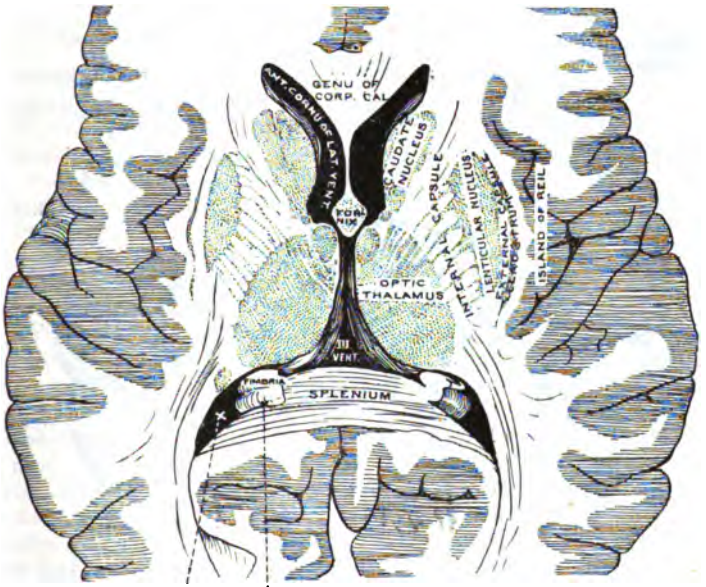

FIG. 574.—HORIZONTAL SECTION OF THE BRAIN THROUGH THE GENU AND SPLENIUM OF THE CORPUS CALLOSUM (DALTON).

The narrow portion is directed outwards and backwards in the floor of the body of the lateral ventricle, where it lies on the outer side of the optic thalamus, from which it is separated by the tænia semicircularis. Its tapering tail is continued into the roof of the descending cornu of the lateral ventricle, and is prolonged in the roof as far as the amygdaloid nucleus, in which it terminates. The nucleus caudatus is composed of grey matter, and its cells are of the multipolar variety.

The **nucleus lenticularis** is embedded in the white matter of the cerebral hemisphere, and lies on the outer side of the nucleus

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caudatus and optic thalamus, from both of which it is separated by the internal capsule. It is of more limited extent than the nucleus caudatus, and receives its name from the fact that, in horizontal section, it presents the appearance of a biconvex lens, the broadest part being on a level with the front of the optic thalamus. Anteriorly it is closely related to the front part of the nucleus caudatus, being continuous with it inferiorly, and connected with it superiorly by striæ of grey matter which intersect the white matter of the front part of the internal capsule. The anterior part of the nucleus lenticularis, as seen in coronal section,

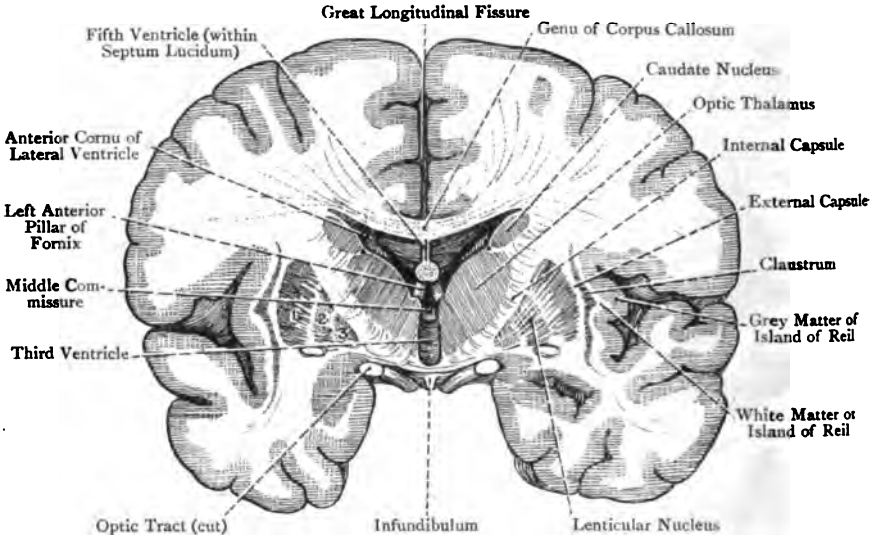

FIG. 575.—CORONAL SECTION OF THE FRONTAL PORTIONS OF THE CEREBRAL HEMISPHERES, PASSING THROUGH THE ANTERIOR CORNUA OF THE LATERAL VENTRICLES (POSTERIOR VIEW).

1, Putamen of Lenticular Nucleus; 2, 3, Globus Pallidus of Lenticular Nucleus.

is somewhat semilunar. When such a section is made through the centre, the nucleus presents a triangular outline, the base being directed towards the island of Reil, and having the external capsule in loose connection with it, whilst the internal surface is in contact with the internal capsule. In such a section the nucleus is seen to be traversed vertically by two white bands, called the *medullary laminæ*, which divide it into three zones. The outer zone, which has a dark reddish colour, is the largest, and is called the *putamen*. The inner two zones, which are somewhat yellowish, are together known as the *globus pallidus*. The putamen and globus pallidus, which consist of grey matter, are traversed by white fibres.

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The grey matter of the nucleus caudatus and nucleus lenticularis comes to the surface at the base of the brain in the region of the locus perforatus anticus, where it is continuous with the grey matter of the cerebral cortex.

The **internal capsule** is the thick tract of white matter which lies between the nucleus lenticularis externally, and the nucleus caudatus, tænia semicircularis, and optic thalamus internally. As seen in horizontal section it describes a bend opposite the front part of the optic thalamus. This bend is called the **genu,** and its convexity is directed inwards. The part of the internal capsule in front of the genu is called the **anterior limb.** It forms about one-third of the entire capsule, and its direction is forwards and outwards. The part behind the genu is called the **posterior limb.** It forms about two-thirds of the entire capsule, and its direction is backwards and outwards.

The **anterior limb** of the internal capsule is situated between the front part of the nucleus lenticularis and the nucleus caudatus. Anteriorly it is intersected by the striæ of grey matter which pass between the two nuclei.

The fibres of which the anterior limb is composed are partly centripetal and partly centrifugal, the former being the most numerous. The **centripetal fibres** arise in the optic thalamus, and are arranged in two sets, according to their destination. The *thalamo-frontal fibres*, having traversed the anterior limb, pass to the cortex of the frontal lobe. The *thalamo-striate fibres*, after passing through the anterior limb, enter the nucleus caudatus and nucleus lenticularis. The chief **centrifugal fibres** form the *fronto-pontine* tract (cortico-protuberantial fibres). They arise in the cortex of the anterior part of the frontal lobe, and, having traversed the anterior limb of the internal capsule and the inner part of the crusta of the crus cerebri, they enter the pons Varolii, where they terminate in the nucleus pontis. Other centrifugal fibres constitute strio-thalamic, cortico-thalamic or fronto-thalamic, and lenticulo-caudate tracts.

The **posterior limb** of the internal capsule is situated between the back part of the nucleus lenticularis and the optic thalamus, and is prolonged backwards for a little beyond the posterior limit of the nucleus lenticularis. It is therefore conveniently divided into two parts, lenticular, representing the anterior two-thirds, and postlenticular, representing the posterior third.

The *lenticular part* of the posterior limb, like the anterior limb, is composed of centripetal and centrifugal fibres. The **centripetal fibres** arise in the optic thalamus, and their destination is the cerebral cortex. The **centrifugal fibres** represent the *pyramidal* or *motor fibres*, and they occupy the anterior portion of the lenticular part of the posterior limb of the internal capsule. These fibres descend from the Rolandic region of the cerebral cortex. Some of them pass to the nucleus of the facial nerve; others pass to the nucleus of the hypoglossal nerve; but the majority of them are destined for the motor cells in the anterior grey cornu of the spinal cord. The

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fibres which pass to the facial nucleus lie close to the genu, and those which pass to the hypoglossal nucleus lie close behind the facial fibres. The fibres of the pyramidal tract occupy the central portion of the crusta of the crus cerebri in their downward course.

The *postlenticular part* of the posterior limb contains the following sets of fibres: (1) the fibres of the optic radiation, on their way from and to the optic thalamus, external geniculate body, and superior quadrigeminal body; (2) the fibres of the auditory radiation, passing between the auditory region of the temporal lobe and the internal geniculate body; and (3) the fibres of the temporopontine tract (cortico-protuberantial fibres), which pass from the cortex of the temporal lobe through the outer part of the crusta of the crus cerebri to the pons Varolii, where they terminate in the nucleus pontis. The internal capsule is continuous inferiorly with the crusta of the crus cerebri. Superiorly its fibres diverge in a radiating manner on their way to the cerebral cortex, forming the **corona radiata,** the fibres of which are intersected by those of the radiatio corporis callosi.

The **external capsule** is a thin lamina of white matter which is situated on the outer side of the nucleus lenticularis, where it lies between that nucleus and the claustrum. In front of and behind the nucleus lenticularis it is continuous with the internal capsule. The external capsule is, as stated, only loosely connected with the putamen of the nucleus lenticularis. The fibres of which it is composed are probably derived from the anterior white commissure and the optic thalamus.

Connections of the Corpus Striatum.—(1) The nucleus caudatus and nucleus lenticularis are partly continuous with each other, and partly connected by striæ of grey matter. (2) The corpus striatum is connected with the optic thalamus by strio-thalamic and thalamo-striate fibres. (3) The nucleus caudatus is said to be connected with the substantia nigra by a tract of fibres known as the *stratum intermedium*. (4) The nucleus lenticularis is connected with the optic thalamus by the ansa lenticularis. (5) The corpus striatum is connected with the cerebral cortex by cortico-striate fibres.

Development.—The corpus striatum is developed as a thickening of the floor of the cerebral vesicle.

The **claustrum** is a thin lamina of grey matter which is situated on the outer surface of the external capsule. It lies embedded in the white matter which occupies the region between the lenticular nucleus and the island of Reil. Superiorly it is narrow and tapering, but inferiorly it expands and reaches the surface at the base of the brain, in the region of the locus perforatus anticus. Its outer surface presents elevations and intervening depressions, which correspond to the sulci and gyri of the island of Reil.

The claustrum is regarded as an isolated portion of the grey matter of the island of Reil.

The **amygdaloid nucleus** is an oval collection of grey matter which is situated in the anterior part of the temporal lobe, where it lies in the roof of the deep extremity of the descending cornu of the lateral ventricle. The putamen of the nucleus lenticularis lies

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above it; anteriorly it is continuous with the cerebral cortex; inferiorly it receives the narrow part or tail of the nucleus caudatus; and the tænia semicircularis arises from it.

The **tænia semicircularis** is a narrow white band of fibres which, as just stated, arises from the amygdaloid nucleus. The band passes backwards in the roof of the descending cornu of the lateral ventricle, and then it sweeps upwards and forwards into the body of the lateral ventricle, lying between the nucleus caudatus and the optic thalamus. At the foramen of Monro the fibres of the tænia semicircularis pass partly in front of and partly behind the anterior commissure, and they are regarded as terminating in the region of the locus perforatus anticus. Some of the fibres may enter the corresponding anterior pillar of the fornix. The vein of the corpus striatum lies superficial to the tænia semicircularis.

Relation of Structures in the Region of the Corpus Striatum.—When a coronal section has been made the relation of structures, from within outwards, is as follows:

1. Nucleus caudatus.
2. Internal capsule.
3. Nucleus lenticularis.
4. External capsule.
5. Claustrum.
6. Island of Reil.

THALAMENCEPHALON OR DIENCEPHALON.

Third Ventricle.

The third ventricle is the cleft-like interval which is situated, in the median line, between the two optic thalami. It extends from the pineal body posteriorly to the anterior pillars of the fornix in front, is very narrow from side to side, and is deeper in front than behind. The cavity presents a roof, a floor, two lateral walls, an anterior boundary, and a posterior boundary.

The **roof** is formed by a delicate layer of epithelium which extends across between the upper margins of the lateral walls, and is continuous with the ependymal lining of the ventricle. Superficial to this epithelial roof, and intimately connected with it, is the velum interpositum, from the under surface of which the two choroid plexuses of the ventricle project downwards, one on either side of the middle line, each invaginating the epithelium of the roof. The epithelium of the roof is so intimately connected with the velum interpositum that, when the latter is removed, the epithelium comes away with it, and the cavity of the ventricle is exposed. Superficial to the velum interpositum is the body of the fornix, and, above this again, is the body of the corpus callosum.

Summary of the Roof.—To expose the ventricle from above the following structures must be removed, in the order named: (1) the body of the corpus callosum; (2) the body of the fornix; and (3) the velum interpositum, along with the epithelium of the roof.

The floor, which is sloped downwards and forwards, is formed by the structures which lie within the interpeduncular space at

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the base of the brain, these being as follows, from behind forwards: the locus perforatus posticus, the corpora albicantia or mammillaria, and the tuber cinereum, with the upper end of the infundibulum. The tegmenta of the crura cerebri enter, to a certain extent, into the floor posteriorly, and the optic commissure lies across it anteriorly. Above the optic commissure the floor presents a depression, called the *optic recess*, and behind this there is another depression or diverticulum, called the *infundibular recess*. The latter forms the upper part of the infundibulum which leads to the posterior lobe of the pituitary body.

The **lateral wall** is slightly convex, and is formed, for the most part, by the inner surface of the optic thalamus, which has a thick

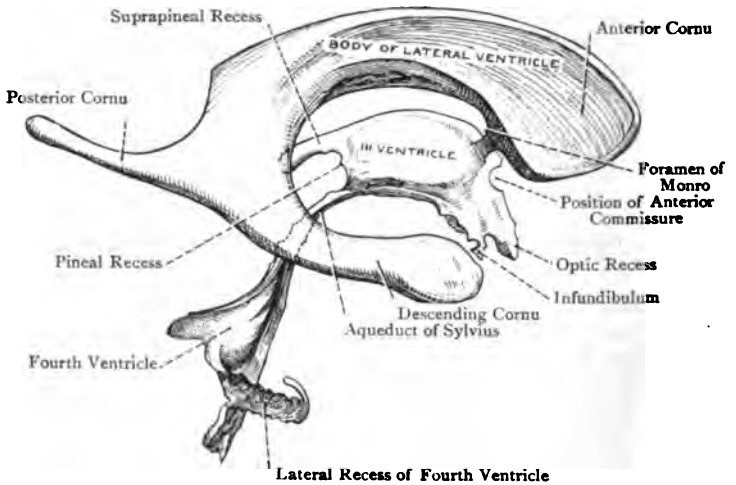

FIG. 576.—DRAWING OF A METAL CAST OF THE VENTRICLES OF THE BRAIN OF AN ADULT (RIGHT LATERAL VIEW) (RETZIUS).

covering of grey matter. Towards its centre it presents a furrow, which leads from the foramen of Monro in a backward direction towards the upper opening of the aqueduct of Sylvius. This groove is called the *sulcus of Monro*. At the upper part of the lateral wall there is a delicate band of white fibres, called the *stria pinealis* or *medullaris*, which represents the dorsal portion of the stalk of the pineal body, and passes to the anterior pillar of the fornix. Connecting the two lateral walls (optic thalami), in front of the centre of the ventricle, there is a fragile band of grey matter, called the **middle** or **soft commissure.** At the anterior part of the lateral wall the corresponding anterior pillar of the fornix passes downwards and backwards.

The **anterior boundary** is formed inferiorly by the lamina cinerea, which extends upwards from the optic commissure to the rostrum

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of the corpus callosum, and superiorly by the anterior pillars of the fornix and the central portion of the anterior commissure.

The **posterior boundary** is formed by the pineal body and the posterior commissure, and under cover of the latter is the upper opening of the aqueduct of Sylvius. The posterior boundary presents two recesses, pineal and suprapineal. The *pineal recess* passes backwards above the posterior commissure into the stalk of the pineal body, separating the stalk into two portions, dorsal and ventral. The *suprapineal recess* is connected with the back part of the epithelial roof of the ventricle, and passes backwards over the pineal body. The third ventricle has thus four diverticula, namely, the optic recess, the infundibular recess, (both of which recesses are associated with the floor), the pineal recess, and the suprapineal recess. The cavity communicates with the fourth ventricle by means of the aqueduct of Sylvius, and with the two lateral ventricles by means of the foramina of Monro.

Foramina of Monro.—These are two in number, right and left, and they lead from the lateral ventricles into the third ventricle. Each foramen is situated between the anterior pillar of the fornix in front and the anterior tubercle of the optic thalamus behind. From this point the foramen of each side leads inwards and slightly downwards, and opens into the third ventricle at the anterior and upper part of the corresponding lateral wall. By means of the foramina of Monro the lateral ventricles communicate with the third ventricle, and, through that ventricle, with each other. The choroid plexuses of the lateral ventricles also become continuous with each other and with those of the third ventricle through these foramina. From each foramen a furrow, called the *sulcus of Monro*, leads, as stated, in a backward direction, over the inner surface of the optic thalamus towards the upper opening of the aqueduct of Sylvius.

Development.—The posterior and greater part of the third ventricle represents the cavity of the thalamencephalon or diencephalon; and the anterior part, in the region of the foramina of Munro, represents the mesial portion of the cavity of the telencephalon.

The foramen of Monro, of each side, represents the original wide communication between the cavity of the cerebral vesicle and the cavity of the mesial portion of the telencephalon.

Optic Thalami.—The optic thalami are two large ovoid masses of grey matter which lie obliquely, with their long axes directed backwards and outwards, for the most part on the sides of the third ventricle. Their anterior extremities are near each other, but their posterior extremities stand apart, the corpora quadrigemina being situated between them. Over their anterior two-thirds they are separated from each other by the third ventricle.

The optic thalamus presents four surfaces—superior, inferior, external, and internal; and two extremities—anterior and posterior.

The **superior surface** is limited externally by an oblique groove,

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which separates it from the nucleus caudatus, and contains the tænia semicircularis and, anteriorly, the vein of the corpus striatum. Internally it is bounded, from before backwards, by (1) the stria pinealis, (2) the trigonum habenulæ, and (3) the

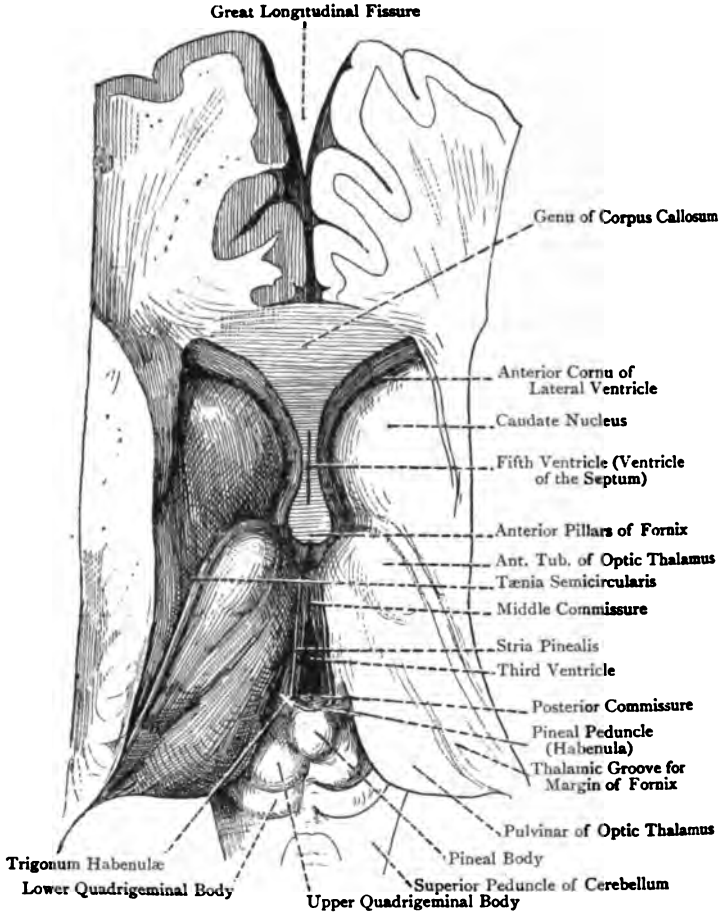

FIG. 577.—THE THIRD VENTRICLE, PORTIONS OF THE LATERAL VENTRICLES, PINEAL BODY, AND CORPORA QUADRIGEMINA (SUPERIOR VIEW) (HENLE).

(The Corpus Callosum, Fornix, and Velum Interpositum have been removed).

corpora quadrigemina. It is divided into two areæ, outer and inner, by a groove which is directed backwards and outwards from the inner border, near the anterior extremity, to the outer end of the posterior extremity. This groove corresponds to the

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lateral margin of the body of the fornix. The *outer area* enters into the body of the lateral ventricle, and is covered by the ependyma of that ventricle. The *inner area* is excluded from the lateral ventricle, and is covered by portions of the velum interpositum and body of the fornix. The superior surface is covered by a thin layer of white fibres, called the *stratum zonale*, these fibres being derived from the optic tract and optic radiation.

The **inferior surface** lies posteriorly upon the upward prolongation of the tegmental fibres of the crus cerebri, which constitutes the subthalamic tegmental region, but anteriorly it rests upon the corpus albicans and a portion of the tuber cinereum.

The **external surface** is directly related to the posterior limb of the internal capsule, which separates it from the nucleus lenticularis. Many fibres emerge from this surface and enter the internal capsule on their way to the cerebral cortex, whilst others from the cerebral cortex enter the optic thalamus through this surface. These fibres constitute the thalamic radiation. On the outer surface the fibres form a well-marked reticular layer of white matter, which is called the *external medullary lamina*.

The **internal surface** faces its fellow of the opposite side, with which it is connected by means of the middle or grey commissure. It forms the lateral wall of the third ventricle, and superiorly is limited by the stria pinealis or medullaris. As stated in connection with the third ventricle, it presents the sulcus of Monro. It is covered by a thick layer of grey matter, which is continuous with that around the aqueduct of Sylvius.

The **anterior extremity** is marked by a prominence, called the *anterior tubercle*, which enters into the body of the lateral ventricle, and forms the posterior boundary of the corresponding foramen of Monro.

The **posterior extremity** presents, at its inner end, a well-marked prominence, called the *posterior tubercle* or *pulvinar*. It lies over the brachia of the corpora quadrigemina, which it almost conceals. Below and external to the pulvinar there is an oval swelling, called the *corpus geniculatum externum*. Below this body is the upper brachium of the corpora quadrigemina, and inferior to this is the *corpus geniculatum internum*.

Structure of the Optic Thalamus.—The optic thalamus is composed chiefly of grey matter. As stated, its superior surface is covered by a layer of white matter, called the *stratum zonale*, and its outer surface by a reticular layer of white matter, known as the *external medullary lamina*, the inner surface having a thick coating of grey matter, continuous with that around the aqueduct of Sylvius. The grey matter of the interior is traversed by a vertical stratum of white matter, called the *internal medullary lamina*, which breaks up into two parts and subdivides the grey matter into three nuclei—anterior, inner, and outer. The *anterior nucleus* is the smallest, and gives rise to the anterior tubercle. The fibres forming the **bundle of Vicq d'Azyr,** which arise in the corpus albi-

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cans, terminate in the cells of this nucleus. The *outer* or *lateral nucleus*, which is the largest, is situated between the internal and external medullary laminæ, and extends backwards into the pulvinar. The *inner* or *mesial nucleus* lies between the internal medullary lamina and the thick layer of grey matter which coats the inner or ventricular surface of the optic thalamus. It does not extend farther back than the trigonum habenulæ, and is consequently excluded from the pulvinar.

Connections of the Optic Thalamus.—(1) Viewing the optic thalamus as an aggregation of 'cell-stations' in the course of the centripetal fibres of the tegmentum of the crus cerebri, the tegmental fibres probably all terminate in the thalamic cells. (2) Through means of the stratum zonale the optic thalamus is connected with the optic tract and optic radiation. (3) The cells of the anterior nucleus receive the fibres of the bundle of Vicq d'Azyr, which are continuous, through the corpus albicans, with the fibres of the anterior pillar of the fornix. (4) **Thalamic Radiation.**—This is composed of **thalamo-cortical fibres** which arise within the optic thalamus as the axons of the thalamic cells. They issue from its external and inferior surfaces, and pass to all parts of the cerebral cortex. They are conveniently arranged in four groups or **stalks**—frontal, parietal, occipital, and inferior or ventral. (*a*) The fibres of the **frontal stalk,** having emerged from the front part of the external surface, traverse the anterior limb of the internal capsule, and most of them pass to the cortex of the frontal lobe. Some of these fibres are thalamo-caudate and thalamo-lenticular, as regards their destination. (*b*) The **parietal stalk**, having issued from the external surface of the optic thalamus, passes for the most part through the internal capsule, but also, to a certain extent, through the external capsule, to the cortex of the parietal lobe, and the Rolandic region of the frontal lobe. (*c*) The **occipital stalk** issues from the outer part of the pulvinar, and, having traversed the postlenticular portion of the posterior limb of the internal capsule, it passes backwards and outwards, external to the posterior cornu of the lateral ventricle, and so reaches the cortex of the occipital lobe. (*d*) The **inferior or ventral stalk** emerges from the front part of the inferior surface of the optic thalamus, and its fibres arise as the axons of the cells of the outer and inner nuclei. The most superficial of these fibres constitute a band, called the *ansa lenticularis*, which enters the nucleus lenticularis, where it terminates. The remaining fibres pass outwards beneath the nucleus lenticularis to the cortex of the temporal lobe and island of Reil.

Besides the thalamo-cortical fibres there are **cortico-thalamic fibres,** which pass from the various parts of the cerebral cortex into the optic thalamus, where they terminate in arborizations around the thalamic cells.

Development.—The optic thalamus is developed as a thickening of the lateral wall of the thalamencephalon or diencephalon.

Corpus Geniculatum Externum.—This body is situated on the posterior extremity of the optic thalamus, where it lies below and external to the pulvinar. It is connected internally with the upper quadrigeminal body by the superior brachium. In structure it is composed of layers of grey and white matter, disposed alternately, the white fibres being derived from the optic tract and optic radiation.

Development.—The corpus geniculatum externum appears as an elevation on the lateral wall of the thalamencephalon or diencephalon.

Subthalamic Tegmental Region.—This region represents the upward prolongation of the tegmental fibres of the crus cerebri

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beneath the posterior portion of the optic thalamus. The parts to be noted are as follows : upward prolongations of the red nucleus and substantia nigra of the tegmentum of the crus cerebri ; the mesial fillet ; the fibres of the superior peduncle of the cerebellum ; and the corpus subthalamicum, or nucleus of Luys. The *red nucleus* and the *substantia nigra* gradually disappear, and are no longer visible at the level of the corpus albicans. The mesial fillet lies on the superficial and outer aspects of the red nucleus. The fibres of the superior peduncle of the cerebellum partly terminate in connection with the cells of the red nucleus, but many of them surround it in the form of a capsule. Beyond the red nucleus the mesial fillet, fibres of the superior cerebellar peduncle, and fibres which issue from the red nucleus enter the inferior surface of the optic thalamus, and terminate in connection with the thalamic cells. Some of these fibres may pass through the optic thalamus into the internal capsule, and thence to the cortex of the Rolandic region of the cerebral hemisphere. The *corpus subthalamicum* or *nucleus of Luys* is a small lenticular mass of grey matter, surrounded by white fibres, which lies on the outer side of the substantia nigra.

Pineal Body (*Epiphysis Cerebri*).—This is a small body, having a dark red colour and conical shape (hence the name *conarium*), which is situated at the back part of the third ventricle. It lies above and behind the posterior commissure, on the superior surface of the mesencephalon, where it occupies the depression between the two upper quadrigeminal bodies. Its base is directed upwards and forwards, and is attached by a peduncle or stalk (*habenula*) of white matter, into which the pineal recess of the third ventricle extends, the suprapineal recess being above the pineal body. By means of the pineal recess the **stalk** is divided into two parts, dorsal and ventral. The *dorsal part* passes outwards and forwards, on either side, along each optic thalamus, at the junction of its inner and upper surfaces, under the name of the **stria pinealis** or **medullaris.** Anteriorly it divides into two parts, upper and lower. The upper division passes upwards, and, joining the anterior pillar of the fornix, it passes to the cells in the hippocampus major. The lower division passes downwards to a group of cells which lies close to the optic commissure. The stria pinealis or medullaris is regarded as belonging to the olfactory apparatus. The *ventral part* of the pineal stalk is bent round the posterior commissure, with which it is connected.

Structure of the Pineal Body.—The pineal body is free from nervous constituents. It consists of a number of follicles, lined with epithelial cells, and containing a variable amount of calcareous matter, called *acervulus cerebri* or *brain-sand*, which is composed of calcium phosphate, calcium carbonate, magnesium phosphate, and ammonium phosphate.

Development.—The pineal body is developed as a diverticulum of the posterior part of the dorsal aspect of the thalamencephalon or diencephalon. This diverticulum for the most part becomes solid, but a portion of it persists as the pineal recess of the third ventricle.

The pineal body is regarded as representing the pineal eye of lizards.

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Trigonum Habenulæ.—This is a small triangular space, which is situated in front of the upper quadrigeminal body, and between the stalk or habenula of the pineal body and the posterior part of the optic thalamus, in the region of the pulvinar. It contains an important group of multipolar nerve-cells, which constitute the **ganglion habenulæ.** The axons of these cells give rise to a bundle of fibres, called the *fasciculus retroflexus*. This bundle appears on the inferior aspect of the ganglion, and passes downwards and forwards in the tegmentum of the crus cerebri, where it lies on the inner side of the red nucleus. Its fibres terminate in connection with the cells of the **ganglion interpeduncular,** which is situated in the lower part of the locus perforatus posticus.

The ganglion habenulæ receives some fibres from the stria pinealis of the same side. The remaining fibres of that stria pass across the median line to the ganglion habenulæ of the opposite side. As the fibres of opposite sides cross they form the dorsal part of the peduncle or habenula of the pineal body, and this decussation of fibres is known as the *habenular commissure.*

Posterior Commissure.—This is a band of white fibres which is situated at the back part of the third ventricle, into the posterior boundary of which it enters. It lies over the upper opening of the aqueduct of Sylvius, and on the inferior aspect of the stalk of the pineal body. The ventral part of the pineal stalk is bent round, and closely connected with, it. The fibres of the posterior commissure are regarded as arising from a nucleus in the grey matter of the ventral aspect of the Sylvian aqueduct, close above the nucleus of the third or oculo-motor nerve. As they cross the middle line they decussate with the fibres of the opposite side, and they may terminate in connection with the cells of the ganglion habenulæ. Its other connections are not definitely known.

Interpeduncular Structures.—These structures are as follows:

1. Locus perforatus posticus.
2. Corpora albicantia.
3. Tuber cinereum.
4. Infundibulum.
5. Pituitary body.

The **locus perforatus posticus** (pons Tarini) is the depressed portion of the interpeduncular space which lies between the crura cerebri as they emerge from the pons Varolii. In other words, it lies directly in front of the pons Varolii. It is covered by a layer of grey matter, which is perforated by a number of apertures for the passage of the postero-mesial branches of the two posterior cerebral arteries.

The **corpora albicantia,** or **mammillaria,** are two small, white, pea-like bodies, which lie side by side directly in front of the locus perforatus posticus. Each is composed of white matter externally, and of a grey nucleus internally. The white matter is derived from the corresponding anterior pillar of the fornix, the fibres of which

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terminate in connection with the cells of the grey nucleus. This grey nucleus contains many cells, the axons of which give rise to two fasciculi, namely, the bundle of Vicq d'Azyr, and the peduncle of the corpus albicans. The **bundle of Vicq d'Azyr,** which is apparently a continuation of the anterior pillar of the fornix, enters the optic thalamus, and its fibres terminate in connection with the cells of the anterior nucleus. The **peduncle of the corpus albicans** passes downwards and backwards in the grey matter of the floor of the third ventricle to the tegmental region of the mesencephalon, but the mode of termination of its fibres is not known.

Development.—The corpora albicantia are developed from the ventral aspect of the thalamencephalon or diencephalon. Up to the fourth month of intra-uterine life they are represented by a single corpus albicans, but after that period this divides into two corpora.

The **tuber cinereum** is an elevated area of grey matter which lies in front of the corpora albicantia and behind the optic commissure, the anterior portion of each optic tract being on either side. It is continuous anteriorly with the lamina cinerea, and on either side with the grey matter of the locus perforatus anticus.

Lamina Cinerea.—This is a thin layer of grey matter which extends from the upper surface of the optic commissure to the rostrum of the corpus callosum. Posteriorly it is continuous with the grey matter of the tuber cinereum, and on either side with that of the locus perforatus anticus.

For the pituitary body and infundibulum, see pp. 1004 and 1005.

Optic Nerve, Optic Commissure, Optic Tract, and Optic Radiation.

The **optic nerves,** or nerves of sight, in the cranial cavity are connected together at the optic commissure, where some of the fibres decussate. From the back part of the commissure each nerve, under the name of the optic tract, passes backwards round the crus cerebri to its cerebral connections.

The **optic commissure** or **chiasma** is somewhat quadrilateral, and rests upon the olivary eminence and optic groove of the sphenoid bone. It lies in front of the tuber cinereum and infundibulum, and its superior surface is connected with the lamina cinerea, and is intimately related to the anterior part of the floor of the third ventricle. Each extremity is connected anteriorly with the optic nerve, and posteriorly with the optic tract. On either side of the commissure is the locus perforatus anticus. The most of the fibres of the commissure proceed from each retina in the corresponding optic nerve, being afferent or centripetal; but at the back part of the commissure there are the fibres of the inner roots of the optic tracts, which have no connection with either retina. The decussation of fibres in the commissure is only partial. The fibres which arise in the nasal or inner half of the retina cross and enter the optic tract of the opposite side. The fibres which

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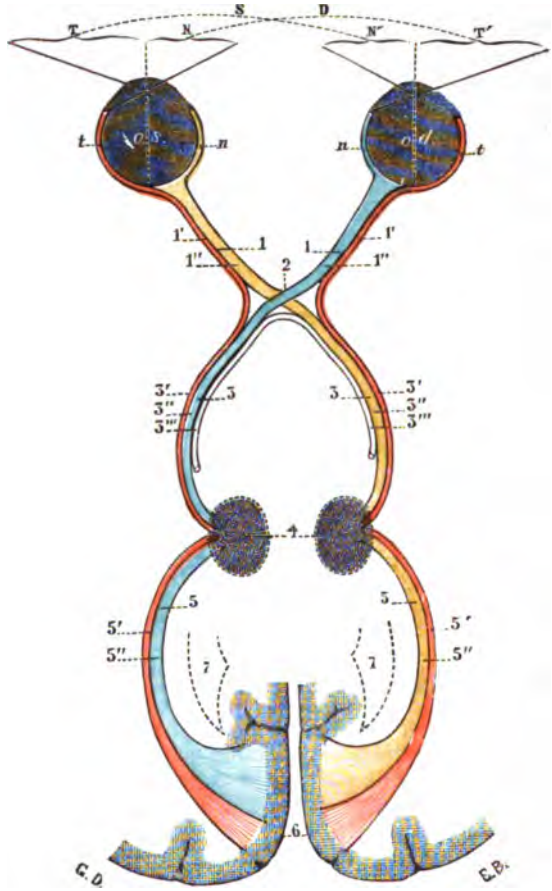

FIG. 578.—SCHEME INDICATING THE COURSE OF THE OPTIC NERVE-FIBRES FROM THE RETINA TO THE CEREBRAL CORTEX (L. TESTUT'S 'ANATOMIE HUMAINE').

o.s. Left Eye
o.d. Right Eye
t. Temporal Zone of Retina
n. Nasal Zone of Retina
T.N. Temporal and Nasal Portions of the Field of Vision for the Left Eye
T'N'. The corresponding portions of the Right Eye
D. The Right Half, and S, the Left Half, of the Field of Vision

1. Optic Nerve
1'. Its Direct Fibres (in red)
1''. Its Crossed Fibres (in yellow on left side, and blue on right side)
2. Optic Commissure
3. Optic Tract
3'. Direct Fibres of Optic Tract
3''. Crossed Fibres of Optic Tract
3'''. Commissure of Gudden
4. Nuclei of Interruption
5. Optic Radiation
5'. Direct Fibres
5''. Crossed Fibres
6. Cerebral Cortex (Mesial Aspect of Occipital Lobe)
7. Posterior Cornu of Lateral Ventricle

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arise in the temporal or outer half of the retina take no part in the decussation, but pass directly backwards into the optic tract of the same side.

Occupying the back part of the commissure there are, as stated, some fibres which have no connection with either retina. These fibres constitute the **commissure of Gudden.** They lie behind the decussating fibres, and represent the fibres of the inner root of the optic tract of each side. They constitute the innermost fibres of each optic tract, and they connect the internal geniculate body of one side with its fellow of the opposite side.

Summary.—The fibres which arise in the nasal or inner half of one retina cross in the optic commissure, and enter the optic tract of the opposite side. The fibres which arise in the temporal or outer half of one retina pass directly backwards into the optic tract of the same side. The fibres of the inner root of each optic tract cross in the back part of the commissure, and form the commissure of Gudden, the fibres of which have no connection with the optic nerves, but connect the two internal geniculate bodies, right and left. The optic commissure therefore consists of the following groups of fibres: (1) The **crossed fibres,** which arise in the nasal or inner portion of each retina; (2) the **uncrossed fibres,** which arise in the temporal or outer portion of each retina, and occupy the outer part of the commissure; and (3) the fibres of the commissure of Gudden, which occupy the back part of the commissure.

The **optic tract** of each side is a flattened white band which passes backwards from the optic commissure. It curves round the crus cerebri, and in the region of the posterior extremity of the optic thalamus it divides into two roots, outer and inner. The **outer** or **visual root** is the larger of the two. It is chiefly composed of afferent fibres, which pass from the retina to the brain; but it also contains efferent fibres, which pass from the brain to the retina. The afferent fibres are derived from (1) the temporal or outer half of the retina of the same side, and (2) the nasal or inner half of the retina of the opposite side, the latter having crossed in the optic commissure. The fibres of the outer root terminate in the external geniculate body, the pulvinar of the optic thalamus, and the upper quadrigeminal body, reaching the last-named body through the superior brachium. They form arborizations around the cells of these bodies which constitute the terminal nuclei or *lower visual centres* of the outer or visual root. These lower visual centres are connected with the higher or cortical visual centre by the strand of fibres forming the **optic radiation,** the higher visual centre being situated in the cortex of the cuneate and lingual gyri of the mesial surface of the occipital lobe. The **inner** or **commissural root** of the optic tract passes beneath the internal geniculate body, which represents the nucleus of most of its fibres. As stated, these fibres have no connection with the optic nerve. Having traversed the inner part of the optic tract, they cross in the back part of the optic commissure, behind the decussating fibres, and are continuous with the corresponding fibres of the opposite side. These are the fibres which constitute the commissure of Gudden.

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Summary of the Optic Tract.—The outermost fibres of each optic tract form the outer portion of the optic nerve of the same side. Most of the other fibres cross in the optic commissure, and form the inner portion of the optic nerve of the opposite side. The innermost fibres cross in the back part of the optic commissure, and form the commissure of Gudden.

Optic Radiation.—The strand of fibres which forms the optic radiation connects the lower visual centres with the higher or cortical visual centre. The fibres are both centripetal and centrifugal. After emerging from the external geniculate body, the pulvinar of the optic thalamus, and the upper quadrigeminal body, the fibres traverse the postlenticular part of the internal capsule. They then pass backwards into the white substance of the occipital lobe, where they lie on the outer surface of the posterior cornu of the lateral ventricle, from which they are separated by fibres of the tapetum. From this region they pass in a radiating manner to the higher or cortical visual centre in the cortex of the occipital lobe, more particularly the cortex of the cuneate and lingual gyri, close to the calcarine fissure on the mesial surface of the lobe.

The lower visual centres are regarded as being connected with the nuclei of origin of the nerves which supply the ocular muscles, probably through means of the posterior longitudinal bundle.

Mesencephalon.

The mesencephalon is composed of the corpora quadrigemina, which form its upper or dorsal portion; the crura cerebri, which form its lower or ventral portion; and the aqueduct of Sylvius, which passes through it from the fourth ventricle below to the third ventricle above.

Corpora Quadrigemina.—These are four rounded eminences, which, as just stated, form the dorsal portion of the mesencephalon. They are covered by the splenium of the corpus callosum, and are arranged in pairs, upper and lower, the upper pair (*nates*) being larger than the lower pair (*testes*), but not quite so prominent. The four eminences are separated from each other by two grooves, longitudinal and transverse, which are arranged in a crucial manner. The longitudinal groove extends upwards as far as the posterior commissure, and it separates the upper and lower quadrigeminal bodies of one side from those of the other side. Its upper part lodges the pineal body, and from its lower part a band of white fibres, called the *frenulum veli*, passes downwards to the superior medullary velum or valve of Vieussens, which lies below the lower pair of eminences. The transverse groove separates the upper pair of quadrigeminal bodies from the lower pair. Laterally each eminence is connected with a white band, called the **brachium**, the two brachia being separated by a continuation of the transverse groove.

The **superior brachium** extends outwards and forwards from the

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upper quadrigeminal body to the external geniculate body and the outer root of the optic tract. It passes between the pulvinar of the optic thalamus and the internal geniculate body.

The superior brachium contains two sets of fibres, namely, **retinal fibres,** derived from the outer root of the optic tract, and (2) **occipital fibres,** from the cortex of the occipital lobe of the cerebrum.

The **inferior brachium** passes upwards from the lower quadrigeminal body to the under aspect of the internal geniculate body, which is a small oval mass on the lateral aspect of the mesencephalon, under cover of the pulvinar of the optic thalamus.

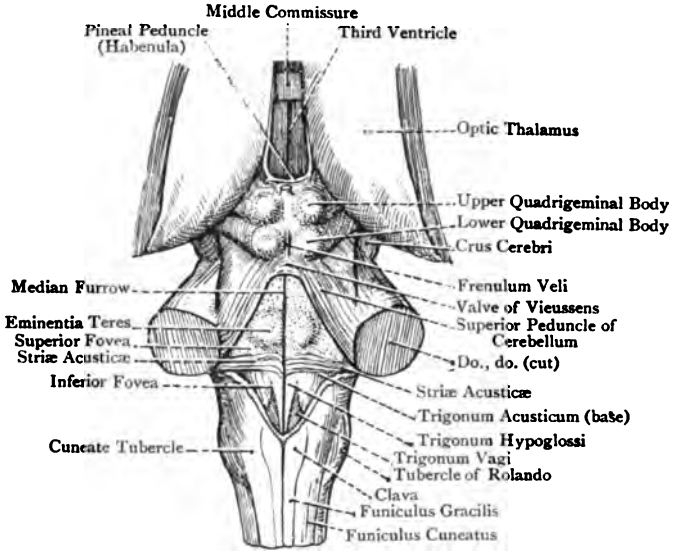

FIG. 579.—THE FLOOR OF THE FOURTH VENTRICLE AND ADJACENT PARTS.

Though the inner root of the optic tract is connected with the internal geniculate body, the inferior brachium passes clear of it, and the most of its fibres are traceable to the optic thalamus through the tegmentum.

Structure.—The **lower quadrigeminal body,** of each side, is composed of a central nucleus of grey matter, which is almost completely surrounded by white fibres. The nucleus contains many multipolar cells, and is traversed by delicate fibres, which are derived from the inferior brachium and the lateral fillet, some fibres of the latter being also disposed superficially. The fibres of the lateral fillet are derived from the corpus trapezoides of the pons Varolii, and have crossed from the opposite side, where they are connected with the central nucleus of the cochlear division of the auditory nerve. The lower quadrigeminal body is therefore to be regarded as associated with the auditory apparatus.

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The **upper quadrigeminal body** is composed of four layers, namely, the stratum zonale, stratum cinereum, stratum opticum, and stratum lemnisci.

The **stratum zonale** is placed superficially, and is composed of white retinal fibres, which are derived from the outer root of the optic tract. The **stratum cinereum** lies beneath the stratum zonale, and consists of a crescentic layer of grey matter. The third layer or **stratum opticum** consists of grey matter and occipital fibres, the latter being derived from the cortex of the occipital lobe of the cerebrum. The last layer, or **stratum lemnisci,** like the stratum opticum, is composed of grey matter and fibres, the latter being derived from the fillet.

The upper quadrigeminal body is one of the three lower visual centres, the other two being the external geniculate body and the pulvinar of the optic thalamus. It derives its fibres from (1) the fillet, which enters the stratum lemniscum, and (2) the superior brachium, which, as stated, consists of

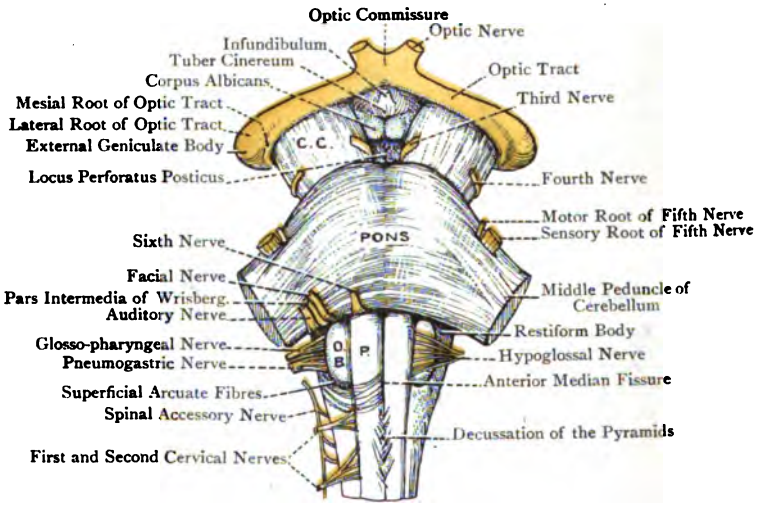

FIG. 580.—THE MEDULLA OBLONGATA, PONS VAROLII, AND INTERPEDUNCULAR REGION.

C.C., Crus Cerebri; P., Pyramid; O.B., Olivary Body.

(*a*) retinal fibres, from the outer root of the optic tract, and (*b*) occipital fibres, from the higher or cortical visual centre in the cortex of the occipita lobe of the cerebrum.

Development.—The corpora quadrigemina are developed as thickenings of the dorsal wall of the mesencephalon.

Commissure of Meynert.—This commissure or decussation consists of fibres which issue from each upper quadrigeminal body and cross to the opposite posterior longitudinal bundle, in which they descend towards the pons Varolii.

Corpus Geniculatum Internum.—This is a small oval mass, which is situated on the lateral aspect of the mesencephalon, under cover of the pulvinar of the optic thalamus. It receives the fibres of the inner root of the optic tract, and, through means of the com-

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missure of Gudden, the right and left internal geniculate bodies are connected with each other. The inferior brachium from the lower quadrigeminal body passes beneath it on its way to the optic thalamus.

Development.—The corpus geniculatum internum appears as an elevation on the lateral wall of the thalamencephalon or diencephalon.

Crura Cerebri.—The crura cerebri form the ventral portion of the mesencephalon. They are two in number, right and left, and emerge from the upper part of the pons Varolii, lying at first close together, but afterwards diverging, as they pass upwards and outwards to enter the cerebral hemispheres. The inner surface of each crus presents a furrow, called the *oculo-motor sulcus*, from which the fasciculi of the third cranial or oculo-motor nerve emerge just above the pons Varolii; and the fourth cranial nerve lies on its outer surface. At the place where the crus enters the cerebral hemisphere it is embraced externally by the optic tract.

Each crus is composed of two parts, dorsal and ventral. The *dorsal* portion is called the **tegmentum,** and the *ventral* portion is known as the **crusta** or **pes.** These two parts are separated from each other in the interior by a mass of dark grey matter, called the **substantia nigra.** The separation between them externally is indicated on either side by a groove. The groove on the outer aspect of the crus is known as the *lateral sulcus*, and that on the inner surface as the *oculo-motor sulcus*, from the fact that the fasciculi of the oculo-motor nerve emerge through it. The upward prolongation of the tegmentum constitutes the subthalamic tegmental region, and it consists of centripetal fibres which are ascending to the cerebral cortex. The crusta becomes continuous with the internal capsule, and consists of centrifugal fibres which are descending from the cerebral cortex.

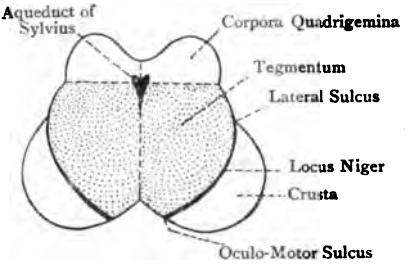

FIG. 581.—TOPOGRAPHY OF THE CRUS CEREBRI (AFTER POIRIER).

Internal Structure of the Crus Cerebri—Tegmentum.—This consists of longitudinal fibres, intersected by transverse fibres, with a large admixture of grey matter in the intervening spaces. It is an upward prolongation of the formatio reticularis of the dorsal portion of the pons Varolii. The two tegmenta, right and left, are intimately connected in the lower part of the mesencephalon, in which situation the two superior cerebellar peduncles decussate. Each tegmentum contains four tracts, namely, (1) the superior cerebellar peduncle, (2) the posterior longitudinal bundle, (3) the lateral fillet, and (4) the mesial fillet.

Superior Cerebellar Peduncle.—The fibres of this peduncle emerge, for the most part, through the hilum of the nucleus den-

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tatus in the cerebellar hemisphere, but some arise from the cerebellar cortex. Underneath the lower pair of quadrigeminal bodies, and on the ventral aspect of the Sylvian aqueduct, the fibres of the two peduncles decussate in the tegmenta. Each bundle, having crossed to the opposite side, enters the upper part of the tegmentum, and comes into contact with a collection of grey matter which has a reddish colour, and is known as the red nucleus. Many of the fibres of the peduncle terminate in this nucleus, but others pass around it, and are continued into the optic thalamus, and, it may be, through it to the cerebral cortex. From the cells of the red nucleus fresh fibres proceed to the optic thalamus; and from the thalamic cells another set of fibres arise which pass to the cerebral cortex, more particularly the cortex of the ascending parietal or postcentral convolution, which lies directly behind the fissure of Rolando. The superior cerebellar peduncle of one side, therefore, connects the cerebellar hemisphere of that side with the Rolandic region of the cerebral cortex of the opposite side, more particularly the post-Rolandic cortex, the red nucleus and the optic thalamus being interposed in the course of most of its fibres.

The **red nucleus,** or **nucleus of the tegmentum,** is a round, reddish mass of grey matter, which is situated in the upper part of the tegmentum in the course of the fibres of the superior cerebellar peduncle of the opposite side. As just stated, many of the fibres of the opposite superior cerebellar peduncle terminate in connection with its cells, and the axons of these cells constitute a fresh set of fibres which carry on the superior cerebellar peduncle to the optic thalamus. The red nucleus is traversed by the fibres of the third cranial nerve, and it is prolonged into the subthalamic tegmental region.

Posterior Longitudinal Bundle.—This bundle is related to the dorsal aspect of the tegmentum, and lies on the ventral aspect of the aqueduct of Sylvius. It is situated close to the median line, and in intimate relation with its fellow of the opposite side. Inferiorly it is continuous with the anterior ground-bundle of the spinal cord, and, after passing through the medulla oblongata and the pons Varolii, it traverses the entire length of the tegmentum as high as the subthalamic tegmental region. In this situation its fibres are regarded as arising from a special nucleus in the grey matter of the floor of the third ventricle, just inferior to the corpus albicans. The posterior longitudinal bundle is intimately related to the nuclei of origin of the nerves of the ocular muscles, namely, the third or oculo-motor nucleus, the fourth or trochlear nucleus, and the sixth or abducent nucleus. Each of these nuclei receives collaterals from the bundle, and probably one of the chief uses of the bundle is to maintain a functional association between these nuclei, and insure harmonious action on the part of the muscles which are supplied by the nerves arising from them.

The posterior longitudinal bundle of one side receives fibres from the upper quadrigeminal body of the opposite side. These fibres decussate with those

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of the opposite side, and constitute the **commissure of Meynert.** Fibres from the third or oculo-motor nucleus are regarded as being conveyed by the posterior longitudinal bundle to the facial nerve, and thence to the orbicularis palpebrarum and corrugator supercilii muscles. According to this view these two muscles are under the control of the same nucleus as the levator palpebræ superioris. Fibres are said to be conveyed by the posterior longitudinal bundle from the sixth or abducent nucleus to that portion of the third or oculo-motor nucleus from which the nerve for the internal rectus muscle of the opposite side arises. This would explain the harmonious action of the external rectus of one side and the internal rectus of the other side in moving the eyeballs to one or other side simultaneously. Fibres may also pass from the hypoglossal nucleus through the posterior longitudinal bundle into the facial nerve, and thence to the orbicularis oris muscle. If this is so, the orbicularis oris and the muscles of the tongue would be under the control of the same nucleus.

Fillet.—There are two tracts with which the name of fillet is associated, namely, the lateral fillet and the mesial fillet.

The **lateral fillet** consists of fibres from the corpus trapezoides in the lower part of the pons Varolii. The sources from which these fibres are derived are as follows: (1) the terminal nuclei of the cochlear division of the auditory nerve of the same, and also of the opposite, side; and (2) the superior olivary nucleus. The lateral fillet ascends through the dorsal or tegmental portion of the pons towards the corpora quadrigemina, and its fibres terminate in (*a*) the lower quadrigeminal body, (*b*) the upper quadrigeminal body, and (*c*) the internal geniculate body.

The lateral fillet is associated with the auditory apparatus.

The **mesial fillet** commences in the lower part of the medulla oblongata, and derives its fibres from the nucleus gracilis and nucleus cuneatus of the opposite side. It is therefore the continuation upwards of the posterior column of the spinal cord. Having traversed the medulla and pons, it enters the tegmentum, and its fibres terminate as follows: (1) some enter the upper quadrigeminal body, and end in the stratum lemniscum; and (2) others pass through the subthalamic tegmental region and enter the optic thalamus, where they end in arborizations around the thalamic cells. From these cells fresh fibres pass to the cerebral cortex.

Crusta or **Pes.**—The crusta or pes is, as stated, the ventral portion of the crus cerebri, and it is separated from the tegmentum of the crus by a mass of dark grey matter, called the substantia nigra, which is situated in the interior. Externally the separation is indicated on the outer aspect by the lateral sulcus, and on the inner aspect by the oculo-motor sulcus, through which the fasciculi of the oculo-motor nerve emerge. The crusta is continuous with the internal capsule of the corpus striatum, and it consists of longitudinal centrifugal fibres, which arise in the cells of the cerebral cortex. These fibres are arranged in two sets, namely, pyramidal and cortico-pontine. The pyramidal fibres form the motor tract from the Rolandic region of the cerebral cortex; and the cortico-pontine fibres are arranged in two strands, namely, fronto-pontine and temporo-pontine.

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The **pyramidal fibres** form the motor tract from the Rolandic region of the cerebral cortex. They traverse the lenticular portion of the posterior limb of the internal capsule, and then occupy the *middle three-fifths* of the crusta. Thereafter they descend through the ventral portion of the pons Varolii and the pyramid of the medulla oblongata. In the lower part of the pyramid they give rise to the crossed and direct pyramidal tracts. The crossed pyramidal tract, having taken part in the decussation of the pyramids, descends in the spinal cord, occupying the posterior part of the lateral column of the opposite side. The direct pyramidal tract descends in the spinal cord, occupying the inner portion of the anterior column of the same side, and forming the column of Türck. Its fibres, however, cross at intervals to the opposite side.

As the pyramidal tract descends through the pons Varolii and medulla oblongata, some of its fibres pass to the motor nuclei of the cranial nerves in these regions.

The **cortico-pontine** or **cortico-protuberantial fibres** are arranged in two strands, fronto-pontine and temporo-pontine. The fibres

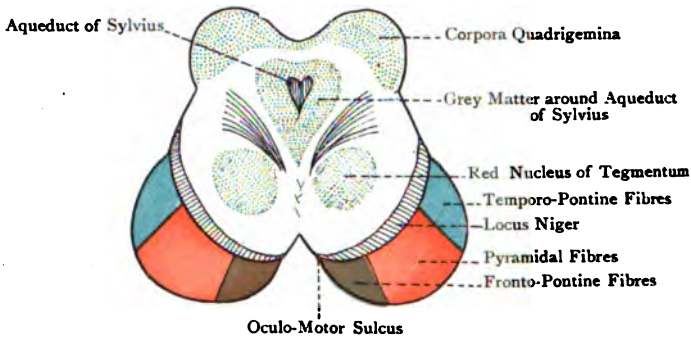

FIG. 582.—TRANSVERSE SECTION OF THE CRUS CEREBRI (AFTER POIRIER).

of the **fronto-pontine strand** arise from the cells of the cortex of the anterior part of the frontal lobe, and, having traversed the anterior limb of the internal capsule, they are regarded as occupying the *inner fifth* of the crusta. The fibres of the **temporo-pontine strand** arise from the cells of the cortex of the temporal lobe, and, having traversed the postlenticular part of the internal capsule, they occupy the *outer fifth* of the crusta. In the ventral part of the pons both the fronto-pontine and the temporo-pontine fibres terminate in arborizations around the cells of the nucleus pontis, whereas the pyramidal fibres pass uninterruptedly through the ventral part of the pons.

Summary of the Crusta.—The crusta is divided into three parts. The middle three-fifths contain the fibres of the pyramidal or motor tract, the inner fifth probably contains the fibres of the fronto-pontine strand, and the outer fifth contains the fibres of the temporo-pontine strand.

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Substantia Nigra.—This is a mass of dark grey matter which is situated between the tegmentum and the crusta of the crus cerebri. Like the crusta, it is semilunar or crescentic, as seen in transverse section. It contains many multipolar nerve-cells, which are deeply pigmented, and it extends from the upper border of the pons Varolii into the subthalamic tegmental region. Laterally it reaches the lateral sulcus on the outer aspect of the crus, where it is thin, and the oculo-motor sulcus on the inner aspect, where it is thick and is traversed by the fasciculi of the third cranial or oculo-motor nerve. Its tegmental surface is concave, and the surface directed towards the crusta is convex. From the latter surface prolongations extend into the crusta.

The substantia nigra is said to be connected with the nucleus caudatus of the corpus striatum by a tract of fibres, called the *stratum intermedium*. The significance of the substantia nigra is not known.

Summary of the Crura Cerebri.—The crura cerebri form the ventral portion of the mesencephalon. Each crus is composed of two parts—dorsal and ventral. The dorsal portion is called the tegmentum, and the ventral portion is called the crusta or pes. The separation between these parts externally is indicated by the lateral sulcus on the outer aspect, and the oculo-motor sulcus on the inner aspect. The internal separation is effected by the substantia nigra. The two tegmenta, right and left, are intimately connected in the lower part of the mesencephalon, in which situation the superior cerebellar peduncles decussate, but the two crustæ are quite distinct from each other. Each **tegmentum** contains three tracts, namely, (1) the superior cerebellar peduncle, (2) the posterior longitudinal bundle, and (3) the fillet.

The two **superior cerebellar peduncles** decussate beneath the lower pair of quadrigeminal bodies, and on the ventral aspect of the Sylvian aqueduct. The fibres of each peduncle, having crossed, partly terminate in the red nucleus in the upper part of the tegmentum, and partly pass around it, and are continued into the optic thalamus. From the cells of the red nucleus fresh fibres arise and pass to the optic thalamus, and from the thalamic cells another set of fibres arise which pass to the cerebral cortex, more particularly the cortex of the ascending parietal or postcentral convolution. The superior cerebellar peduncle of one side, therefore, connects the cerebellar hemisphere of that side with the Rolandic region of the cerebral cortex of the opposite side, more particularly the post-Rolandic cortex, the red nucleus and the optic thalamus being interposed in the course of most of its fibres. The **red nucleus** is situated in the upper part of the tegmentum in the path of the fibres of the superior cerebellar peduncle of the opposite side, for which it acts as a cell-station.

The **posterior longitudinal bundle** is continuous with the anterior ground-bundle of the spinal cord. Its chief significance consists in its intimate relation to the nuclei of origin of the third or oculo-motor, fourth or trochlear, and sixth or abducent nerves, to each of which nuclei it furnishes collaterals. Probably one of the chief uses of the bundle is to maintain a functional association between these nuclei, and insure harmonious action on the part of the muscles which are supplied by the nerves arising from them.

The **fillet** constitutes two tracts, lateral and mesial. The **lateral fillet** consists of fibres from the corpus trapezoides, and these ultimately come from (1) the terminal nuclei of the cochlear division of the auditory nerve of the same side, and also of the opposite side; and (2) the superior olivary nucleus. The fibres of the lateral fillet pass to (*a*) the lower quadrigeminal body, (*b*) the upper quadrigeminal body, and (*c*) the internal geniculate body. The lateral fillet is associated with the auditory apparatus.

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The **mesial fillet** derives its fibres from the nucleus gracilis and nucleus cuneatus of the opposite side, and it is a continuation upwards of the posterior column of the spinal cord. Its fibres pass to (1) the stratum lemniscum of the upper quadrigeminal body, and (2) the optic thalamus, from the cells of which fresh fibres proceed to the cerebral cortex.

The **crusta** or **pes** is divided into three parts. The middle three-fifths contain the fibres of the pyramidal or motor tract; the inner fifth probably contains the fibres of the fronto-pontine strand; and the outer fifth contains the fibres of the temporo-pontine strand.

The **substantia nigra** is situated between the tegmentum and the crusta. Its significance is not known.

Development.—The crura cerebri are developed as thickenings of the ventral wall of the mesencephalon.

Aqueduct of Sylvius.—The aqueduct of Sylvius is the narrow passage which leads through the mesencephalon from the third to the fourth ventricle (*iter a tertio ad quartum ventriculum*). It lies nearer the dorsal than the ventral aspect of the mesencephalon; its direction is from above downwards; and its length is rather more than ½ inch. Its upper opening is situated on the posterior boundary of the third ventricle, immediately underneath the posterior commissure, and its lower opening occupies the superior median angle of the floor of the fourth ventricle. In transverse section the aqueduct is T-shaped in its upper part, near the third ventricle, and triangular in its lower part, near the fourth ventricle. The passage is lined with ciliated columnar epithelium, external to which there is a thick layer of grey matter, which is spoken of as the **Sylvian grey matter.** This is continuous superiorly with the grey matter of the floor and lateral walls of the third ventricle, and inferiorly with that which covers the floor of the fourth ventricle. It contains numerous nerve-cells, disposed in a scattered manner, but, in addition to these, there are certain definite cell-groups. These groups constitute the nuclei of origin of the following cranial nerves: the third or oculo-motor, the fourth or trochlear, and the descending or mesencephalic root of the fifth nerve. The **oculo-motor nucleus** is situated in the ventral portion of the Sylvian grey matter, underneath the upper quadrigeminal body, and it extends upwards into the layer of grey matter on the adjacent portion of the lateral wall of the third ventricle. The **trochlear nucleus** is also situated in the ventral portion of the Sylvian grey matter, but at a lower level than the oculo-motor nucleus, being placed underneath the upper part of the lower quadrigeminal body. The **nucleus of the descending or mesencephalic root of the fifth nerve** is extensive, and is situated in the lateral portion of the Sylvian grey matter.

Development.—The aqueduct of Sylvius is the persistent remains of the cavity of the mesencephalon.

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Structure of the Cerebral Hemispheres.

The cerebral hemisphere is composed of grey and white matter. The grey matter is disposed externally, and forms the cerebral *cortex*. The white matter occupies the interior, and constitutes the *medullary centre*.

Cerebral Cortex.—The grey matter forms a continuous covering to the entire hemisphere, dipping into the sulci, so as to cover the opposed surfaces of the gyri, as well as the bottom of the sulci. It is thicker over the superficial surfaces of the gyri than at the bottom of the sulci, and attains its greatest thickness over the upper portions of the precentral and postcentral gyri, whilst it is thinnest over the occipital lobe. It is the seat of the intellectual and psychical functions, and of consciousness.

The cerebral cortex differs in structure in different regions; but it has certain general characters, which will be now described. It is essentially laminated or stratified, and is composed of superimposed layers of white and grey matter, alternating with each other, these being for the most part four in number, but in some places there are as many as six, *e.g.*, over the precentral gyrus. From without inwards these six layers are disposed as follows: (1) a narrow layer of white matter on the surface; (2) a layer of grey matter; (3) a second narrow layer of white matter, called the **outer band of Baillarger** (band of Vicq d'Azyr); (4) a second layer of grey matter; (5) a third narrow layer of white matter, called the **inner band of Baillarger**; and (6) a third layer of grey matter, which is in close contact with the white matter of the medullary centre. In those regions where there are only four layers, No. 5 cannot be seen, and Nos. 4 and 6 are combined into one layer.

Minute Structure of the Cerebral Cortex.—The cortex is composed of nerve-cells and nerve-fibres.

Nerve-cells.—These are arranged in four layers, which are as follows from without inwards: (1) the molecular layer; (2) the layer of small pyramidal cells; (3) the layer of large pyramidal cells; and (4) the layer of polymorphous cells.

The **molecular layer** (*stratum zonale*), which is the most superficial, is narrow, and is principally composed of tangential fibres, which are disposed horizontally or parallel to the surface of the gyri. The nerve-cells are small, chiefly fusiform, and situated in the deep part of the layer. They lie with their long axes parallel to the surface, and each gives off from either pole a long slender dendrite. These dendrites mingle with the tangential fibres, and give off branches which are directed towards the surface. Besides fusiform cells there are a few triangular cells, each of which sends off dendrites, and one of these becomes the axon of a nerve-fibre.

The **pyramidal layers** represent the second and third layers, and are composed of characteristic pyramidal cells which are peculiar to the cerebral cortex, those of the second layer being small, whilst those of the third layer are large. The layer of small pyramidal

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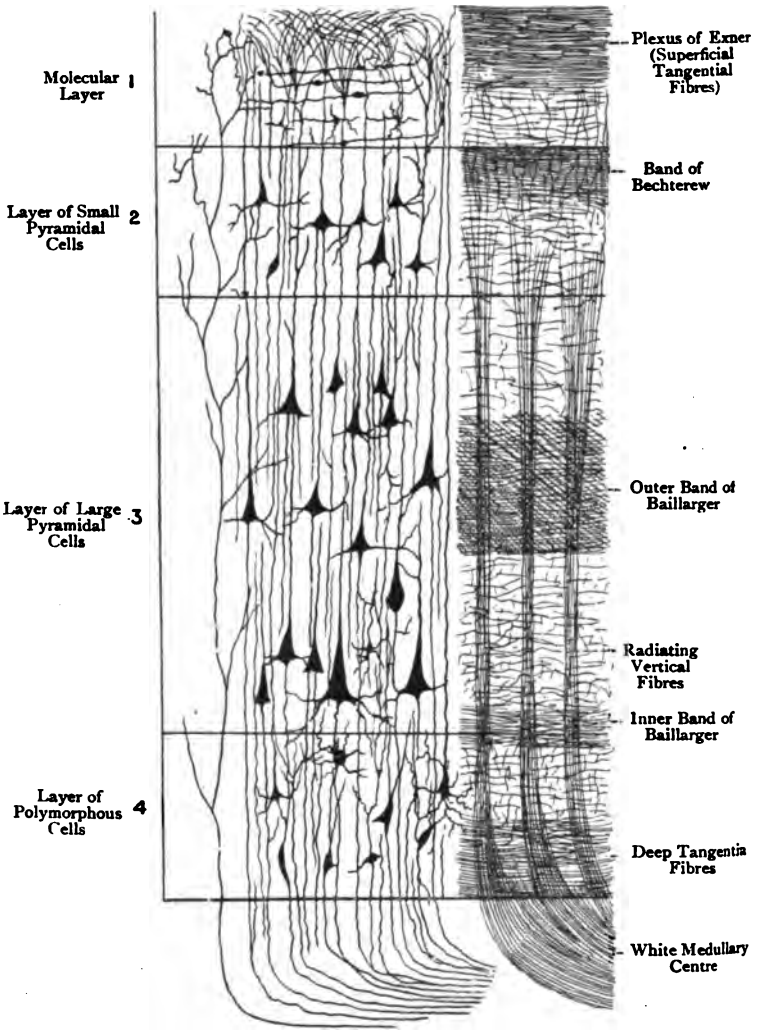
Molecular Layer 1
Layer of Small Pyramidal Cells 2
Layer of Large Pyramidal Cells 3
Layer of Polymorphous Cells 4
Plexus of Exner (Superficial Tangential Fibres)
Band of Bechterew
Outer Band of Baillarger
Radiating Vertical Fibres
Inner Band of Baillarger
Deep Tangentia Fibres
White Medullary Centre

FIG. 583.—DIAGRAM SHOWING THE MINUTE STRUCTURE OF THE CEREBRAL CORTEX (POIRIER).

The Fibres are shown on the right, and the Cells on the left.

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cells is narrow, but the layer of large pyramidal cells is of considerable thickness. There is no well-marked line of demarcation between these two layers, the one passing imperceptibly into the other. They constitute the chief part of the cerebral cortex.

The apex of each **pyramidal cell** is directed towards the surface of the gyrus, and is prolonged into a long tapering dendrite, which passes into the molecular layer, giving off delicate collaterals in its course. Near the surface of the molecular layer it divides into terminal filaments, which are disposed horizontally and mingle with the tangential fibres. The base of the pyramidal cell is directed towards the medullary centre of the gyrus, and from its centre an axon is given off, which enters the medullary centre, giving off collaterals in its course. From each side of the body of the cell, as well as from each lateral angle of its base, dendrites are given off.

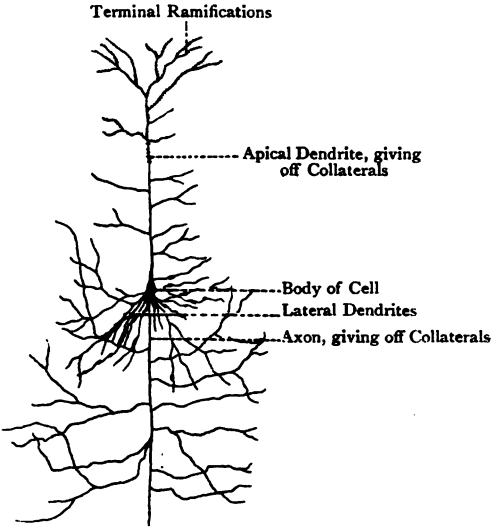

FIG. 584.—A PYRAMIDAL CELL OF THE HUMAN CEREBRAL CORTEX (RAMON Y CAJAL).

The **polymorphous layer** is the deepest layer, and is composed of cells which have different shapes. Each cell gives off several dendrites, which pass towards, but do not enter, the molecular layer. The axon of each cell enters the medullary centre as a nerve-fibre.

In addition to the foregoing cells of the cerebral cortex, two other kinds of cells are met with amongst the pyramidal and polymorphous cells, namely, the cells of Golgi and the cells of Martinotti. The **cells of Golgi** are characterized by the fact that the axon of each almost immediately divides into several branches, which pass towards the surface, but soon terminate without entering the molecular layer. The **cells of Martinotti** are chiefly met with in the polymorphous layer. The axon of each cell passes towards the surface, and enters the molecular layer, where it divides into terminal branches, which form part of the tangential fibres of this layer.

Nerve-fibres of the Cortex.—These are arranged in two groups—vertical and tangential.

The **vertical** (radial) **fibres** are disposed in radiating bundles,

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which issue from the medullary centre, and traverse the polymorphous and large pyramidal layers, after which they become indistinguishable. The polymorphous and large pyramidal cells lie in the spaces between these bundles, and assume a columnar arrangement. The fibres of the radiating bundles gradually become less numerous, some of them becoming the axons of the polymorphous cells, but most of them becoming the axons of the large pyramidal cells. The radiating bundles contain centripetal cortical fibres, which pass into the molecular layer and end in terminal ramifications, forming part of its tangential fibres.

The **tangential fibres** are disposed horizontally at different levels, and form the following strata: (1) the **superficial tangential fibres (plexus of Exner),** which occupy the superficial part of the molecular layer; (2) the **band of Bechterew,** which is situated in the superficial part of the small pyramidal layer; (3) the **outer band of Baillarger** (*band of Vicq d'Azyr*), which intersects the large pyramidal layer; (4) the **inner band of Baillarger,** which is situated between the large pyramidal and polymorphous layers; and (5) the **deep tangential fibres** (*intra-cortical association fibres*), which are situated in the deep part of the polymorphous layer.

The tangential fibres are formed by (1) the collaterals of the polymorphous and pyramidal cells and of the cells of Martinotti: (2) the ramifications of the axons of the cells of Golgi; and (3) association fibres.

Medullary Centre of the Cerebral Hemisphere.—The white matter of the medullary centre consists of medullated nerve-fibres, arranged in bundles, with neuroglia between them. The fibres pursue different courses, and are arranged in three groups, namely, projection fibres, commissural fibres, and association fibres.

Projection Fibres.—The most of these fibres are traceable through the corona radiata into the internal capsule of the corpus striatum, but some of them pass through the lenticular nucleus and external capsule. Beyond these regions they are continued into the crusta and tegmentum of the crus cerebri. The projection fibres therefore connect the cerebral cortex with the parts below. They consist of centripetal (afferent) and centrifugal (efferent) fibres.

The **centripetal fibres** are as follows: (1) thalamic fibres, which arise within the optic thalamus as the axons of its cells, and which form the thalamic radiation; (2) fibres of the superior cerebellar peduncle, which have passed over the red nucleus and through the optic thalamus on their way to the cortex of the Rolandic region of the cerebral hemisphere; (3) a few of the fibres of the fillet, which have passed through the optic thalamus on their way to the cortex of the postcentral gyrus; (4) fibres of the optic radiation, proceeding to the occipital cortex; and (5) fibres of the auditory radiation, proceeding to the temporal cortex.

The **centrifugal fibres** are as follows: (1) The **pyramidal fibres,** which proceed from the cortex of the Rolandic region. Having traversed the corona radiata, these fibres pass, in succession, through

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(*a*) the posterior limb of the internal capsule ; (*b*) the middle three-fifths of the crusta of the crus cerebri ; (*c*) the ventral portion of the pons Varolii ; (*d*) the pyramid of the medulla oblongata, and thence into the spinal cord, partly as the direct pyramidal tract or column of Türck, but chiefly as the crossed pyramidal tract. Ultimately the fibres terminate, at different levels in the spinal cord, in arborizations around the anterior cornual cells, from which the fibres of the anterior or motor nerve-roots proceed. (2) The **fronto-pontine tract,** which consists of fibres proceeding from the cortex of the frontal region in front of the precentral sulcus. These fibres reach the ventral portion of the pons Varolii through the anterior limb of the internal capsule, and probably through the inner or mesial fifth of the crusta of the crus cerebri. In the pons they terminate in arborizations around the cells of the nucleus pontis. (3) The **temporo-pontine tract,** the fibres of which proceed from the temporal cortex through the postlenticular part of the posterior limb of the internal capsule and the outer fifth of the crusta, to the ventral portion of the pons, where they end in arborizations around the cells of the nucleus pontis. (4) The **optic radiation,** the fibres of which pass from the occipital cortex through the postlenticular part of the posterior limb of the internal capsule to the external geniculate body, pulvinar, and upper quadrigeminal body.

Commissural Fibres.—These fibres are disposed transversely, and serve to connect the grey cortex of one hemisphere with that of the other. They constitute the following commissures : (1) the corpus callosum ; (2) the anterior commissure ; and (3) the lyra or psalterium, which is known as the hippocampal commissure. The fibres of the **corpus callosum,** as they enter each hemisphere, are disposed so as to form an extensive **callosal radiation,** and serve to connect the cortex of one hemisphere with that of the other. The individual portions of cortex so connected may be symmetrical, but to a large extent they are asymmetrical. The fibres arise on one side as (1) the axons of pyramidal or of polymorphous cells, or (2) collaterals of projection or of association fibres ; and on the opposite side they terminate in delicate arborizations.

The **anterior commissure,** which crosses from side to side in front of the anterior pillars of the fornix, divides on either side into two parts, olfactory and temporal. The *olfactory portion* enters the olfactory tract. Some of its fibres serve to connect the olfactory bulb of one side with that of the other side ; and other fibres connect the olfactory bulb of one side with the temporal lobe of the opposite. The *temporal portion* enters the white matter of the temporal lobe on either side.

The **lyra** or **psalterium** consists of transverse fibres which connect the hippocampus major of one side with its fellow of the opposite side ; hence the name **hippocampal commissure.**

Association Fibres.—These fibres serve to connect different parts

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of the cortex of the same hemisphere, and they are of two kinds, short and long.

The **short association fibres** pass between contiguous gyri, extending in their course across the bottom of the sulci. Some of them lie beneath the grey cortex, whilst others are contained within its deep part.

The **long association fibres** pass between portions of the grey cortex, which are at some distance from each other. They are arranged in bundles, the chief of which are as follows: (1) the superior longitudinal fasciculus; (2) the inferior longitudinal fasciculus; (3) the perpendicular fasciculus; (4) the uncinate fasciculus; (5) the cingulum; (6) the occipito-frontal fasciculus; and (7) the fornix.

The **superior longitudinal fasciculus** consists of fibres which extend from the frontal to the occipital lobe. Posteriorly many of its fibres sweep downwards and forwards into the temporal lobe, and from this circumstance it is sometimes spoken of as the **arcuate fasciculus.**

The **inferior longitudinal fasciculus** connects the occipital and temporal lobes, its fibres being disposed upon the outer walls of the posterior and descending cornua of the lateral ventricle.

The **perpendicular fasciculus** connects the inferior parietal gyrus with the occipito-temporal gyrus.

The **uncinate fasciculus** crosses the stem of the fissure of Sylvius, and connects the frontal and temporal lobes.

The **cingulum** is connected with the limbic lobe, and lies upon the under surface of the callosal gyrus and the upper surface of the hippocampal gyrus. Its fibres connect the gyri of the limbic lobe with the cerebral cortex.

The **occipito-frontal fasciculus** connects the frontal with the occipital and temporal lobes. According to Dejerine the *tapetum* of the corpus callosum belongs to this fasciculus, and not to the corpus callosum. The fasciculus lies internal to the corona radiata, in intimate relation to the nucleus caudatus, and, as the fibres pass backwards, they lie on the outer walls of the descending and posterior cornua of the lateral ventricle.

The **fornix** connects the hippocampus major of one side with the corresponding corpus albicans, and, through the latter, with the optic thalamus by means of the bundle of Vicq d'Azyr, the fibres of which arise in the corpus albicans.

Peculiarities of the Cerebral Cortex—1. **Calcarine Area.**—This area is situated on the mesial surface of the occipital lobe, in close proximity to the calcarine fissure, and it is known as the **visual area.** In this region the outer band of Baillarger is very conspicuous, whilst the inner band of Baillarger is absent.

2. **Rolandic Area.**—In this region, more especially in the cortex of the precentral gyrus, there are groups of very large pyramidal cells, which are known as the **giant-cells of Betz,** and nerve-fibres are present in large numbers.

3. **Hippocampal Area.**—The hippocampus major corresponds to the hippocampal or dentate fissure, and is produced by an infolding of the cerebral

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cortex. It is therefore composed chiefly of grey matter, and is covered superficially by a thin layer of white matter, called the **alveus,** which is continuous with the fimbria. The hippocampus major is composed of the following layers, named in order from the ventricular surface outwards: (1) the **alveus,** composed of white matter, and covered by the ventricular ependyma; (2) **neuroglial layer,** consisting of neuroglia fibres and cells; (3) **pyramidal layer,** composed of large pyramidal cells; (4) **stratum radiatum,** which is the outer part of the pyramidal layer, and is composed of the dendrites of the apical parts of the pyramidal cells, being thereby rendered striated in appearance; (5) **stratum lacinlosum,** composed of the ramifications of the foregoing apical dendrites, intimately intermixed; (6) **stratum granulosum,** composed of many small cells; and (7) the **involuted medullary lamina,** consisting of white fibres.

Olfactory Tract and Olfactory Bulb.—These are developed as a hollow outgrowth from the anterior cerebral vesicle, more particularly from the part of it which ultimately gives rise to the lateral ventricle, and is known as the **telencephalon.** In many animals the central cavity persists, and maintains its connection with the lateral ventricle; but in man the cavity disappears, though traces of its ependymal lining remain. External to the vestigial ependyma there is a layer of white matter, and, superficial to this, there is a layer of grey matter. In the **olfactory tract** the layer of grey matter is very thin over the ventral or inferior aspect, but over the dorsal or superior aspect it is fairly thick. In the **bulb** the reverse is the case, the grey matter being thick over the ventral aspect, where it receives the olfactory filaments, but thin over the dorsal aspect.

Structure of the Ventral Grey Matter of the Olfactory Bulb.—The grey matter consists of three layers, namely (1) the nerve-fibre layer, (2) the glomerular layer, and (3) the granular layer.

The **nerve-fibre layer** is the most superficial layer, and is composed of olfactory nerve-fibres. These fibres are non-medullated, and arise as the axons of the olfactory cells of the olfactory mucous membrane of the nasal fossa. Having passed through the foramina of one half of the cribriform plate of the ethmoid bone, they enter the grey matter on the ventral aspect of the bulb, where they break up and form arborizations. These intermingle with the arborizations formed by the dendrites of the mitral cells, to be presently described.

The **glomerular layer** is composed of round bodies or *glomeruli,* which are formed by the interlacements between the arborizations of the olfactory nerve-fibres and those of the dendrites of the mitral cells.

The **granular layer** lies next to the layer of white matter, and is chiefly characterized by the presence of large **mitral cells.** These are pyramidal, and one dendrite from each cell passes into the glomerular layer, where it gives rise to a glomerulus in the manner just described in connection with the glomerular layer. Other dendrites intermingle with those of adjacent mitral cells. The axon of each mitral cell enters the white layer of the bulb, and passes along the olfactory tract to the cerebrum.

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Weight of the Brain.—The average weight of the brain of the adult male is about 48 ounces, and that of the adult female about 44 ounces.

Arteries of the Encephalon.

Cerebral Part of the Internal Carotid Artery.—The internal carotid artery, having pierced the roof of the cavernous sinus, internal to the anterior clinoid process of the sphenoid bone, ascends between the second and third cranial nerves to the inner end of the stem of the fissure of Sylvius. Here it divides into its terminal branches, namely, anterior cerebral and middle cerebral.

Branches.—These are as follows: posterior communicating anterior choroidal, anterior cerebral, and middle cerebral.

The **posterior communicating artery** arises from the back part of the internal carotid, and passes backwards to anastomose with the posterior cerebral artery. It is usually of small size, but is occasionally large, and it furnishes twigs to the crus cerebri and inner aspect of the optic thalamus.

The **anterior choroidal artery** arises from the back part of the internal carotid close to its termination. It passes backwards and outwards between the crus cerebri and the hippocampal gyrus, and it enters the lower and anterior extremity of the descending cornu of the lateral ventricle by passing through the choroidal fissure. In its course it gives twigs to the hippocampal gyrus and crus cerebri, and it terminates in the choroid plexus of the lateral ventricle.

Anterior Cerebral Artery.—This is the smaller of the two terminal branches of the internal carotid artery, and it has a more limited distribution than the other terminal branch, namely, the middle cerebral artery. It passes forwards and inwards, above the optic nerve, to the commencement of the great longitudinal fissure, where it is connected with its fellow of the opposite side by a short transverse vessel, called the **anterior communicating artery.** Thereafter it enters the great longitudinal fissure, along with its fellow, turns round the genu of the corpus callosum, and passes backwards over the upper surface of that body to the splenium, where it anastomoses with the posterior cerebral artery.

Branches.—These are arranged in two groups, antero-mesial or ganglionic and cortical.

The **antero-mesial** or **ganglionic branches,** small in size, pass through the lamina cinerea, along with twigs from the anterior communicating artery, and supply the front part of the caudate nucleus.

The **cortical branches** are as follows: (1) **internal orbital,** to the internal orbital gyrus, olfactory lobe, and gyrus rectus; (2) **anterior internal frontal,** to the superior frontal gyrus, the anterior two-thirds of the middle frontal gyrus, and the anterior part of the marginal gyrus; (3) **middle internal frontal,** to the callosal gyrus, the posterior part of the marginal gyrus, and the upper part of the precentral gyrus; and (4) **posterior internal frontal,** to the quadrate

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lobule and the corpus callosum, the branch to the latter being known as the *artery of the corpus callosum*.

Anterior Communicating Artery.—This vessel connects the two anterior cerebral arteries at the entrance to the great longitudinal fissure, and lies over the lamina cinerea, in front of the optic commissure. It gives off a few twigs, which accompany the antero-mesial branches of each anterior cerebral artery.

Middle Cerebral Artery.—This is the larger of the two terminal branches of the internal carotid artery, and it has a wider distribution than the anterior cerebral artery. It enters the stem of the fissure of Sylvius, in which it passes outwards.

Branches.—These are arranged in two groups, antero-lateral or

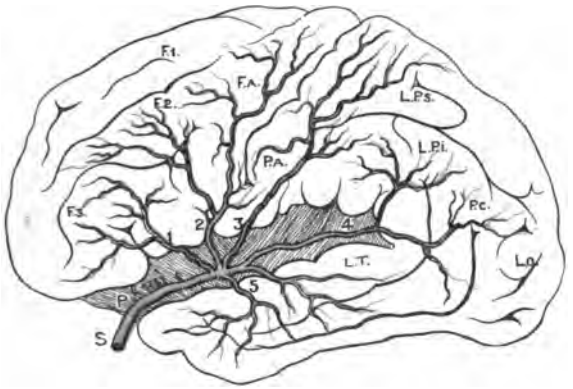

FIG. 585.—DISTRIBUTION OF THE LEFT MIDDLE CEREBRAL ARTERY (CHARCOT).

F.1. Superior Frontal Gyrus
F.2. Middle Frontal Gyrus
F.3. Inferior Frontal Gyrus
F.A. Ascending Frontal Gyrus
P.A. Ascending Parietal Gyrus
L.P.S. Superior Parietal Gyrus
L.P.I. Inferior Parietal Gyrus
P.C. Angular Gyrus
L.O. Occipital Lobe
L.T. Temporal Lobe

S. Middle Cerebral Artery entering Fissure of Sylvius
P. Lenticulo-striate Arteries
1. Artery to Broca's Gyrus (Inferior Frontal Gyrus)
2. Ascending Frontal Artery
3. Ascending Parietal Artery
4. Parieto-Temporal Artery
5. Arteries to Temporal Lobe

ganglionic and cortical. The **antero-lateral** or **ganglionic branches** pass through the locus perforatus anticus, and form two sets, internal striate and external striate. The **internal striate arteries** represent the lenticular arteries of Duret, and they supply the globus pallidus (inner part) of the lenticular nucleus, the internal capsule, and the caudate nucleus. The **external striate arteries** represent the lenticulo-striate and lenticulo-optic arteries of Duret. The **lenticulo-striate arteries** supply the putamen (outer part) of the lenticular nucleus and the external capsule. One of the lenticulo-striate arteries is larger than the others, and is subject to rupture in cases of cerebral hæmorrhage. It is known as the *artery of cere-*

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bral hemorrhage (Charcot). Its course is outwards and upwards round the outer aspect of the lenticular nucleus, between it and the external capsule, and then through the internal capsule to the caudate nucleus. The **lenticulo-optic arteries** supply the posterior part of the lenticular nucleus and the anterior part of the optic thalamus on its outer aspect.

The **cortical branches** arise in the vicinity of the island of Reil, and are as follows : (1) **inferior external orbital,** to the orbital surface of the frontal lobe external to the internal orbital sulcus, and to the inferior frontal gyrus ; (2) **ascending frontal,** to the posterior

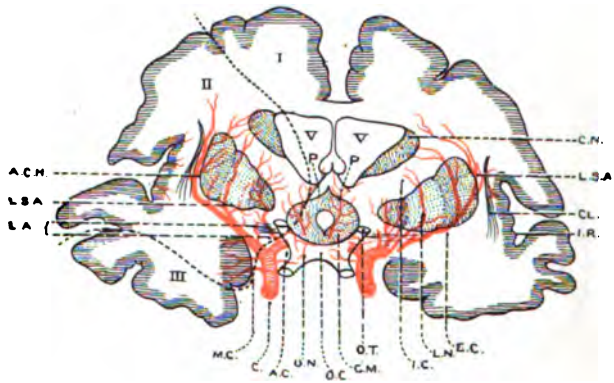

FIG. 586.—CORONAL SECTION OF THE CEREBRAL HEMISPHERES MADE ONE CENTIMETRE BEHIND THE OPTIC COMMISSURE (CHARCOT, FROM DURET).

(The Arteries of this region are shown).

I. Area of Anterior Cerebral Artery
III. Area of Middle Cerebral Artery
III. Area of Posterior Cerebral Artery
V.V. Sections of Anterior Cornua of Lateral Ventricles
P.P. Anterior Pillars of Fornix
C.N. Caudate Nucleus
L.S.A. Lenticulo-Striate Arteries
CL. Claustrum
I.R. Island of Reil
E.C. External Capsule
L.N. Lenticular Nucleus
I.C. Internal Capsule
O.T. Optic Tract (cut)
C.M. Grey Matter of Third Ventricle
O.C. Optic Commissure
O.N. Optic Nerve
A.C. Anterior Cerebral Artery
C. Internal Carotid Artery
M.C. Middle Cerebral Artery
L.A. Lenticular Arteries
A.C.H. Artery of Cerebral Hemorrhage

third of the middle frontal gyrus, and to the lower and greater part of the precentral gyrus ; (3) **ascending parietal,** to the postcentral gyrus and superior parietal gyrus : (4) **parieto-temporal,** which traverses the posterior horizontal limb of the fissure of Sylvius, and supplies the inferior parietal gyrus, and the posterior parts of the superior and middle temporal gyri ; and (5) the **temporal branches,** which emerge from the posterior horizontal limb of the fissure of Sylvius, and supply the anterior and greater parts of the superior and middle temporal gyri.

Fourth or Intracranial Part of the Vertebral Artery.—The verte-

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bral artery, on leaving the suboccipital triangle, pierces the dura mater and arachnoid, and enters the cranial cavity through the foramen magnum. As it ascends, it lies at first on the side of the medulla oblongata, between the hypoglossal nerve and the anterior root of the suboccipital nerve. It then passes upwards on the ventral surface of the medulla, and, on reaching the lower border of the pons Varolii, it unites with its fellow of the opposite side to form the basilar artery.

Branches.—These are as follows: posterior meningeal, posterior spinal, posterior inferior cerebellar, anterior spinal, and bulbar.

The **posterior meningeal artery** arises from the vertebral artery just before it pierces the dura mater, and it enters the cerebellar fossa of the occipital bone where it supplies the dura mater.

The **posterior spinal** artery arises from the vertebral artery immediately after it has pierced the dura mater. It descends upon the side of the spinal cord, in front of the posterior roots of the spinal nerves, and it gives off a branch which descends behind these roots. These two arteries, in themselves small, are reinforced by the spinal branches of the second part of the vertebral artery and of the dorsal branches of the intercostal arteries. In this manner lateral anastomotic arterial chains are formed upon each side of the spinal cord, in front of, and behind, the posterior nerve-roots.

The **posterior inferior cerebellar artery,** of large size, arises a little above the preceding branch. It passes backwards between the pneumogastric and spinal accessory nerves, and then over the restiform body to the vallecula of the cerebellum, where it divides into branches. Some of these supply the inferior vermis, and others ramify on the inferior surface of the cerebellar hemisphere, at the periphery of which they anastomose with branches of the superior cerebellar artery. The artery furnishes branches to the corresponding choroid plexus of the fourth ventricle and to the medulla oblongata.

The **anterior spinal branch** of the vertebral artery arises from that vessel near its termination. It passes obliquely downwards and inwards over the ventral aspect of the medulla oblongata, and at the median line it unites with its fellow of the opposite side to form the **anterior spinal artery** of the spinal cord. It furnishes twigs to the medulla oblongata.

The **bulbar branches** are distributed to the medulla oblongata.

Basilar Artery.—This vessel is formed by the union of the two vertebral arteries. It extends from the lower to the upper border of the pons Varolii, occupying the median basilar groove on its ventral surface. It lies beneath the arachnoid membrane, within the *cisterna pontis*, and at the upper border of the pons it divides into the two posterior cerebral arteries.

Branches.—These are as follows, on either side: transverse, internal auditory, anterior inferior cerebellar, superior cerebellar, and posterior cerebral.

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The **transverse** or **pontine arteries** are numerous, and pass outwards on either side to supply the pons, the sensory and motor roots of the fifth cranial nerve, and the middle peduncle of the cerebellum.

The **internal auditory artery**, long and slender, accompanies the auditory nerve through the internal auditory meatus, and is distributed to the internal ear.

The **anterior inferior cerebellar artery** arises from the centre of the basilar, and passes backwards to be distributed to the anterior part of the inferior surface of the cerebellar hemisphere. It anastomoses with the posterior inferior cerebellar artery, which is a branch of the vertebral.

The **superior cerebellar artery** arises from the basilar close to its

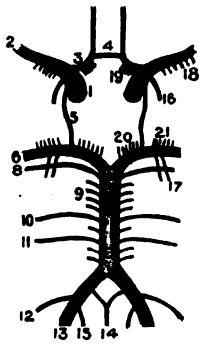

FIG. 587.—THE ARTERIES AT THE BASE OF THE BRAIN, AND THE CIRCLE OF WILLIS.

1. Internal Carotid
2. Middle Cerebral
3. Anterior Cerebral
4. Anterior Communicating
5. Posterior Communicating
6. Posterior Cerebral
7. Basilar
8. Superior Cerebellar
9. Transverse Pontine
10. Internal Auditory
11. Anterior Inferior Cerebellar
12. Posterior Inferior Cerebellar
13. Vertebral
14. Anterior Spinal
15. Posterior Spinal
16. Anterior Choroid
17. Posterior Choroid
18. Central or Ganglionic
19. Central or Ganglionic
20. Central or Ganglionic (Postero-mesial)
21. Central or Ganglionic (Postero-lateral)

termination. It passes outwards, parallel to the posterior cerebral artery, from which it is separated by the third cranial nerve. It then winds round the outer side of the crus cerebri, below the fourth cranial nerve, and so reaches the superior surface of the cerebellar hemisphere, where it divides into branches. These supply the superior vermis, the valve of Vieussens, the velum interpositum, and the superior surface of the cerebellar hemisphere, at the periphery of which they anastomose with branches of the inferior cerebellar arteries.

Posterior Cerebral Artery.—This is one of the terminal branches of the basilar artery, at the upper border of the pons Varolii. It passes at first outwards, beneath the crus cerebri, and parallel to the superior cerebellar artery, from which it is separated by the

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third cranial nerve. It then winds round the outer side of the crus cerebri, lying between it and the hippocampal gyrus, and above the fourth cranial nerve. In this manner it reaches the tentorial or inferior and mesial surfaces of the occipital lobe of the cerebral hemisphere. It receives, not far from its commencement, the posterior communicating artery.

Branches.—These are arranged in two groups—ganglionic and cortical.

The **ganglionic group** includes three sets of branches, namely, postero-mesial, postero-lateral, and posterior choroidal.

The **postero-mesial ganglionic arteries** pass internal to the crus cerebri, and pierce the locus perforatus posticus. They supply the inner part of the crus cerebri and the posterior part of the optic thalamus.

The **postero-lateral ganglionic arteries** pass on the outer side of the crus cerebri, and supply the outer part of the crus, the posterior part of the optic thalamus, the corpora quadrigemina, and the corpora geniculata.

The **posterior choroidal arteries** are two or three in number, and pass through the choroidal fissure to the velum interpositum, which they supply, together with the choroid plexus of the lateral ventricle, and the corresponding choroid plexus of the third ventricle.

The **cortical branches** are as follows: (1) **anterior temporal,** to the anterior parts of the occipito-temporal and hippocampal gyri; (2) **posterior temporal,** to the posterior parts of the occipito-temporal and hippocampal gyri, and the inferior temporal gyrus; and (3) **occipital,** to the occipital lobe. One of the occipital branches is called the **calcarine artery.** It lies in the calcarine fissure, and supplies the lingual or infracalcarine gyrus and the cuneus.

Circle of Willis.—This circle is formed by (1) the anastomoses which take place between (*a*) the internal carotid and posterior cerebral arteries, through means of the posterior communicating arteries, and (*b*) the anterior cerebral arteries, through means of the anterior communicating artery; and (2) the connection between the two posterior cerebral arteries which is established by the basilar artery. It is situated at the base of the brain, and, though spoken of as a circle, it is really a heptagon—that is to say, it has seven sides and seven angles.

The circle is formed *in front* by the anterior communicating artery, which connects the two anterior cerebral arteries; *behind,* by the basilar artery, as it divides into the two posterior cerebral arteries; and *on either side* by (1) the anterior cerebral artery, (2) the trunk of the internal carotid artery, (3) the posterior communicating artery, and (4) the posterior cerebral artery, in this order from before backwards. The circle of Willis furnishes twigs to the grey cortex of the interpeduncular region. It serves to equalize the blood-pressure in the cerebral arteries, and it also provides for the regular supply of blood to the brain in cases where one of the main arterial trunks may be obstructed.

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The following parts are contained within the circle of Willis, in order from behind forwards: (1) the locus perforatus posticus; (2) the corpora albicantia or mammillaria; (3) the tuber cinereum and infundibulum; and (4) the optic commissure or chiasma.

Veins of the Encephalon.

The **cerebral veins** are arranged in two groups—superficial and deep.

The **superficial cerebral veins** are divided into two sets—superior and inferior.

The **superior cerebral veins** return the blood from the upper parts of the outer surfaces of the cerebral hemispheres. They lie in the pia mater, and pierce the arachnoid membrane and inner layer of the dura mater, after which they open into the superior longitudinal sinus, having previously received the veins from the mesial surface of either hemisphere. Their direction, for the most part, is forwards and inwards, whilst the direction of the blood-current in the superior longitudinal sinus is backwards.

The **inferior cerebral veins** return the blood from the lower parts of the cerebral hemispheres, and they terminate in the cavernous, superior petrosal, and lateral sinuses. One of these veins is known as the **middle cerebral,** or **superficial Sylvian, vein.** It passes along the fissure of Sylvius, and opens into the front part of the cavernous sinus. This vein communicates posteriorly with (1) the superior longitudinal sinus, through means of the great or superior anastomotic vein; and (2) the lateral sinus, through means of the posterior anastomotic vein.

The **deep cerebral veins** are as follows: (1) the choroidal veins; (2) the veins of the corpora striata; (3) the veins of Galen; (4) the anterior cerebral veins; (5) the deep Sylvian veins; and (6) the basilar veins.

The **choroidal vein** of each side commences in the choroid plexus of the descending cornu of the lateral ventricle. It ascends at first, and then passes forwards in the lateral margin of the velum interpositum to the foramen of Monro, where it unites with the vein of the corpus striatum to form the corresponding vein of Galen.

The **vein of the corpus striatum** is formed by branches which issue from the corpus striatum and optic thalamus. It runs forwards in the groove between these two bodies, lying superficial to the tænia semicircularis, and at the foramen of Monro it joins the choroidal vein to form, as stated, the corresponding vein of Galen.

The **vein of Galen,** of each side, is formed close to the foramen of Monro by the union of the choroidal vein, and the vein of the corpus striatum. The two veins of Galen, right and left, pass backwards between the two layers of the velum interpositum, and they unite, beneath the splenium of the corpus callosum, to form one vessel, called the **vena magna Galeni,** which opens into the front part of the straight sinus. Each vein of Galen receives tributaries from

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the optic thalamus, the corresponding choroid plexus of the third ventricle, the corpus callosum, and the corpora quadrigemina; and, prior to joining its fellow, it takes up the basilar vein of its own side. The **vena magna Galeni** receives tributaries from the upper surface of the cerebellum.

The **anterior cerebral vein** of each side is situated in the great longitudinal fissure, along with the corresponding artery. Having curved round the genu of the corpus callosum it passes to the region of the locus perforatus anticus, where it joins the deep Sylvian vein to form the basilar vein.

The **deep Sylvian vein** returns the blood from the island of Reil, and lies deeply within the stem of the fissure of Sylvius. At the locus perforatus anticus it joins the anterior cerebral vein to form, as stated, the basilar vein.

The **basilar vein** of each side commences at the locus perforatus anticus, where it is formed by the union of the anterior cerebral and deep Sylvian veins. It passes backwards round the crus cerebri, and opens into the vein of Galen of its own side, just before that vessel joins its fellow to form the vena magna Galeni. The basilar vein receives, close to its commencement, one or more inferior striate veins, which descend from the corpus striatum through the locus perforatus anticus. It also receives tributaries from the parts within the interpeduncular space.

The **cerebellar veins** are arranged in two groups—superior and inferior.

The **superior cerebellar veins** terminate in the vena magna Galeni, and in the straight, lateral, and superior petrosal sinuses. The **inferior cerebellar veins** pass to the lateral, inferior petrosal, and occipital sinuses.

Blood-supply of the Different Parts of the Encephalon.

The **medulla oblongata** is supplied by the vertebral, anterior spinal, and posterior inferior cerebellar arteries.

The **pons Varolii** is supplied by the transverse or pontine branches of the basilar artery.

The **cerebellum** is supplied *inferiorly* by the posterior inferior cerebellar branches of the vertebral arteries, and the anterior inferior cerebellar branches of the basilar artery. *Superiorly* it is supplied by the superior cerebellar branches of the basilar artery, and, to a limited extent, by the posterior inferior cerebellar arteries.

The **crus cerebri** is supplied by the postero-mesial and postero-lateral branches of the posterior cerebral artery, and by the posterior communicating artery.

The **locus perforatus posticus** is pierced by the postero-mesial branches of the posterior cerebral arteries.

The **corpora quadrigemina** are supplied by the postero-lateral branches of the posterior cerebral arteries.

The **optic thalamus** is supplied *posteriorly* by the postero-mesial and postero-lateral branches of the posterior cerebral artery. *Anteriorly* its outer part is supplied by the lenticulo-optic branches of the middle cerebral artery, and its inner part by the posterior communicating artery.

The **locus perforatus anticus** is pierced by the antero-lateral ganglionic branches of the middle cerebral artery.

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Frontal Lobe.—The superior frontal gyrus, the anterior two-thirds of the middle frontal gyrus, and the upper portion of the precentral gyrus are supplied by cortical branches of the anterior cerebral artery. The posterior third of the middle frontal gyrus, the inferior frontal gyrus, and the lower and greater part of the precentral gyrus are supplied by cortical branches of the middle cerebral artery. On the orbital surface the internal orbital gyrus, olfactory lobe, and gyrus rectus are supplied by the anterior cerebral artery, whilst the remainder is supplied by the middle cerebral artery.

Parietal Lobe.—The whole of this lobe is supplied by the middle cerebral artery.

Occipital Lobe.—This lobe is supplied by the posterior cerebral artery.

Temporal Lobe.—The superior and middle temporal gyri are supplied by the middle cerebral artery, and the remainder is supplied by the posterior cerebral artery.

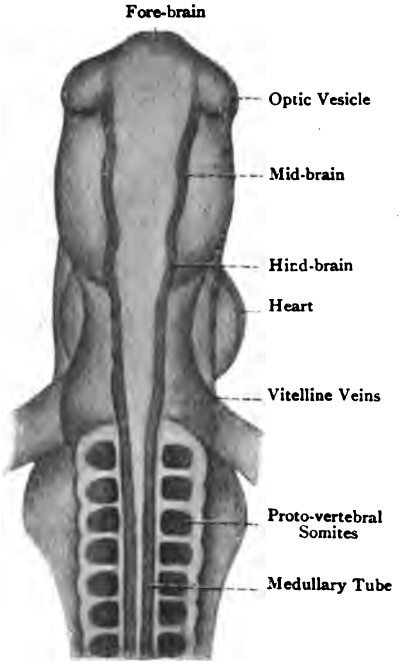

FIG. 588.—ANTERIOR PART OF AN EMBRYO CHICK AT THE END OF THE SECOND DAY (DORSAL VIEW) (KÖLLIKER).

Mesial Surface of the Cerebral Hemisphere.—The anterior cerebral artery has an extensive distribution to this surface, which it supplies as far back as the internal part of the parieto-occipital fissure. The parts behind this fissure, namely, the cuneus and the parts around the calcarine fissure, are supplied by the posterior cerebral artery.

The **corpus callosum** is supplied by the anterior cerebral arteries.

Corpus Striatum.—The **nucleus caudatus** and **nucleus lenticularis** are supplied, for the most part, by the antero-lateral or ganglionic branches of the middle cerebral artery, which pass through the locus perforatus anticus. According to Duret they form three sets—lenticular, lenticulo-striate, and lenticulo-optic. The **lenticular** (internal striate) **arteries** supply the globus pallidus (inner part) of the lenticular nucleus, the internal capsule, and the caudate nucleus. The **lenticulo-striate** (external striate) **arteries** supply the putamen (outer part) of the lenticular nucleus, and the external capsule. One of the lenticulo-striate arteries is larger than the others, and is subject to rupture in cases of cerebral hæmorrhage. It is known as the *artery of cerebral hemorrhage* (Charcot). Its course it outwards and upwards round the outer aspect of the lenticular nucleus, between it and the external capsule, and then through the internal capsule to the caudate nucleus. The **lenticulo-optic arteries** supply the posterior part of the lenticular nucleus, and the anterior part of the optic thalamus on its outer aspect.

The front part of the caudate nucleus is supplied by the antero-mesial branches of the anterior cerebral and anterior communicating arteries.

The larger arteries occupy the subarachnoid space, where they divide into branches which enter the pia mater. These in turn give off smaller branches, which enter the cerebral substance, some of them being cortical, and others medullary, in their distribution.

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Blood-supply of the Choroid Plexuses.—The **choroid plexus of the lateral ventricle** derives its blood from (1) the anterior choroidal artery, which is a branch of the internal carotid; and (2) the posterior choroidal arteries, which are branches of the posterior cerebral. The **choroid plexuses of the third ventricle** derive their blood from the posterior choroidal arteries. The **choroid plexuses of the fourth ventricle** derive their blood from the posterior inferior cerebellar arteries.

The **velum interpositum** derives its blood from the posterior choroidal arteries and from the superior cerebellar arteries.

Lymphatics of the Brain.—There are no lymphatic vessels in the brain. Their place is taken by spaces in the outer coat of the arteries, called **perivascular spaces**, which are in communication with the subarachnoid space.

Development of the Brain.

The brain is developed from the cephalic portion of the **neural tube.** This portion of the tube undergoes enlargement, and is divided by constrictions into the anterior, middle, and posterior primary cerebral vesicles. The *anterior cerebral vesicle* forms the **prosencephalon** or **fore-brain**; the *middle cerebral vesicle* forms the **mesencephalon** or **mid-brain**; and the *posterior cerebral vesicle* forms the **rhombencephalon** or **hind-brain.**

Subsequently the anterior and posterior primary cerebral vesicles become subdivided, each into two, thus giving rise to five vesicles, namely, first, second, third, fourth, and fifth, in this order from before backwards, these being known as the secondary cerebral vesicles.

The *first* vesicle forms the **telencephalon,** the *second* the **thalamencephalon** or **diencephalon,** the *third* the **mesencephalon,** the *fourth* the **metencephalon,** and the *fifth* the **myelencephalon.**

These formations will be made clear from the following table:

Anterior primary cerebral vesicle = Prosencephalon, or fore-brain = Telencephalon and Thalamencephalon or Diencephalon = First secondary vesicle; Second secondary vesicle

Middle primary cerebral vesicle = Mesencephalon, or mid-brain = Third secondary vesicle

Posterior primary cerebral vesicle = Rhombencephalon, or hind-brain = Metencephalon = Fourth secondary vesicle; Myelencephalon = Fifth secondary vesicle

The parts of the encephalon, formed from the foregoing subdivisions, are as follows:

Telencephalon.	**Thalamencephalon,** or **Diencephalon.**
Cerebral hemispheres.	Posterior part of third ventricle.
Lateral ventricles.	Optic thalami.
Anterior part of third ventricle.	Pineal body.
Foramina of Monro.	Interpeduncular structures.
Olfactory lobes.	Pituitary body.
	Optic nerve and retina.

Mesencephalon.	**Metencephalon.**	**Myelencephalon.**
Corpora quadrigemina.	Cerebellum.	Medulla oblongata or bulb.
Crura cerebri.	Pons Varolii.	Bulbar part of the fourth ventricle.
Aqueduct of Sylvius.	Pontine part of the fourth ventricle.	

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The earliest change in the primitive brain takes the form of two hollow protrusions, called the **primary optic vesicles,** which grow outwards from the lateral parts of the anterior primary cerebral vesicle, one on either side. Each of these optic vesicles becomes enlarged at its terminal extremity, and the narrow portion, which connects it to the anterior cerebral vesicle, is known as the **optic stalk.** When the prosencephalon becomes divided into telencephalon and thalamencephalon or diencephalon, the optic vesicle is connected with the latter. It gives rise to the **optic nerve** and **retina.**

The next change in the primitive brain consists in the appearance of two other hollow protrusions, called the **vesicles of the cerebral hemispheres,** which grow forwards from the anterior primary cerebral vesicle, and subsequently upwards and backwards. The cavity of each **cerebral vesicle** gives rise to the corresponding **lateral ventricle.** The **corpus striatum,** of each side, is developed from the floor of the cerebral vesicle, and the **olfactory lobe** grows as a hollow protrusion from the antero-inferior part of the cerebral

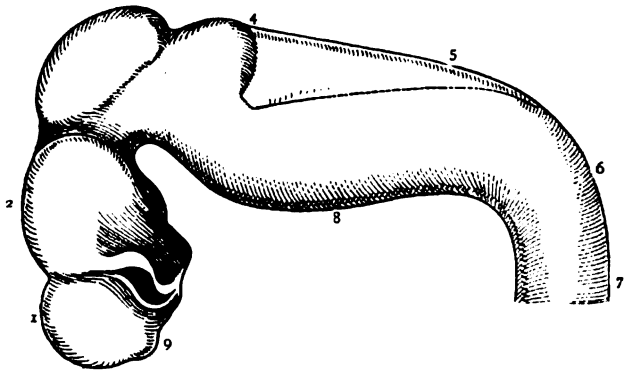

FIG. 589.—BRAIN OF AN EMBRYO ABOUT THREE AND A HALF WEEKS OLD. FROM QUAIN'S 'ANATOMY' (HIS).

1. Telencephalon
2. Thalamencephalon
3. Mesencephalon
4. Metencephalon
5. Myelencephalon
6. Cervical Flexure
7. Spinal Cord
8. Pontine Flexure
9. Olfactory Lobe

1, 2 = Prosencephalon; 3 = Mesencephalon; 4, 5 = Rhombencephalon

vesicle. This protrusion becomes solid, and gives rise to the **olfactory tract** and **olfactory bulb.**

The **choroidal fissure** is formed by an infolding of the mesial wall of the cerebral vesicle in the region of the foramen of Monro. Mesoblastic tissue gradually extends into the interval between the two layers of this fold—that is to say, into the choroidal fissure—and this tissue gives rise to the choroid plexus of the lateral ventricle.

The *anterior part* of the **third ventricle,** in the region of the foramina of Monro, is developed from the telencephalon; and the *posterior* and *greater part* represents the cavity of the thalamencephalon or diencephalon.

From the roof of the thalamencephalon a hollow protrusion grows upwards and forwards for a short distance in the median line, which gives rise to the **pineal body.** Another hollow protrusion grows downwards from the floor of the thalamencephalon. The lower part of this diverticulum becomes transformed into a reticulum of connective tissue, permeated by branched cells. This part forms the posterior lobe of the **pituitary body,** and the remainder of the diverticulum gives rise to the **infundibulum,** which remains

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hollow in its upper part. The posterior and greater part of the third ventricle is developed from the cavity of the thalamencephalon. The **optic thalamus** of each side is developed in the lateral wall of the thalamencephalon.

The **corpora quadrigemina** are developed in the roof of the mesencephalon (middle primary cerebral vesicle); the **crura cerebri** are developed in its floor; and the **aqueduct of Sylvius** is a persistent part of its cavity.

The upper or pontine part of the fourth ventricle is developed from the cavity of the metencephalon (fourth secondary cerebral vesicle); the cerebellum is developed in its roof; and the pons Varolii is formed in its floor.

The lower or bulbar part of the fourth ventricle is developed from the cavity of the myelencephalon (fifth secondary cerebral vesicle), and the medulla oblongata or bulb is developed in its ventral wall.

The primitive brain, which is at first in line with the primitive spinal cord, subsequently undergoes several bends. The *first bend* is situated opposite the base of the middle primary cerebral vesical or mesencephalon, its concavity being ventrally placed. The effect of this bend is to direct the anterior primary cerebral vesicle or prosencephalon towards the ventral surface. The *second bend*, which is deep, is situated between mesencephalon and the posterior primary cerebral vesicle or rhombencephalon, its concavity being dorsally placed. The *third bend* is situated between the myelencephalon and the spinal cord. Its concavity is ventrally placed, and it causes the medulla oblongata to be gradually bent towards the ventral surface.

MENINGES OF THE ENCEPHALON.

Dura Mater.

The dura mater is a strong fibrous membrane which surrounds the encephalon, and is composed of two layers—outer and inner. The **outer** or **periosteal layer** serves as the internal periosteum or endocranium of the cranial bones, and the **inner** or **sustentacular layer** supports the encephalon. It is more firmly adherent to the bones forming the base of the skull than over the cranial vault, and it is also firmly attached along the course of the sutures. At the various openings it is prolonged outwards, blending with the sheaths of the transmitted nerves, and also becoming continuous with the external periosteum or pericranium. At the sphenoidal fissure it passes into the orbit to form the orbital periosteum. At the lower margin of the foramen magnum the two layers of which the dura mater is composed separate. The external layer blends with the periosteum of the occipital bone around the margin of the foramen magnum. The internal layer is prolonged into the spinal canal, and forms the theca of the spinal cord. The outer surface of the dura mater is rough and flocculent, owing to fibrous processes which connect it to the inner surfaces of the cranial bones. Its inner surface is smooth and covered by endothelium. Superiorly, on either side of the superior longitudinal sinus, there are several small granular nodules, called **Pacchionian bodies**, which are best marked in old age. They indent the parietal bone, and protrude into the superior longitudinal sinus, carrying with them prolongations from the endothelial lining of the sinus, which separate them from the blood.

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The Pacchionian bodies are enlargements of the villi of the arachnoid membrane (see p. 1366).

Structure.—The dura mater consists of fibrous and elastic tissues, arranged as parallel bundles.

The intracranial dura mater differs from the dura mater of the spinal cord in the following respects : (1) it consists of two layers—outer or periosteal, and inner or sustentacular—whereas the spinal dura mater has only one layer, representing the sustentacular layer; (2) it furnishes certain processes or septa, which project into the cranial cavity, and separate parts of the encephalon from each other, whereas the spinal dura mater sends no septa into the spinal cord ; and (3) it contains venous sinuses, which are absent in the spinal dura mater.

Subdural Space.—This is the interval between the dura mater and the arachnoid membrane. There is really no space, but simply sufficient interval to contain a minute quantity of serous fluid for lubricating purposes. The dura mater and the arachnoid are therefore practically in contact with each other.

Blood-supply.—The cranial dura mater is supplied by the **meningeal arteries,** which are also distributed to the inner table and diploë of the cranial bones. These vessels are very numerous, and the chief are as follows on either side, from before backwards : (1) anterior meningeal, two in number, from the anterior and posterior ethmoidal arteries ; (2) meningeal, from the cavernous part of the internal carotid artery ; (3) small meningeal, from the middle meningeal, or from the first part of the internal maxillary artery ; (4) middle meningeal, from the first part of the internal maxillary ; (5) meningeal branches of the ascending pharyngeal artery ; (6) posterior meningeal branch of the occipital artery ; and (7) posterior meningeal, from the vertebral artery.

The **anterior meningeal branch of the anterior ethmoidal artery** arises from that vessel as it accompanies the nasal nerve on the cribriform plate of the ethmoid bone, and it takes part in the supply of the dura mater of the anterior fossa.

The **anterior meningeal branch of the posterior ethmoidal artery** arises from that vessel after it has entered the cranial cavity through a minute foramen between the cribriform plate of the ethmoid and the sphenoid. It has a limited distribution to the dura mater in this region.

The **meningeal branch of the internal carotid artery** arises from the cavernous part of that vessel, and enters the middle fossa to supply the dura mater.

The **small meningeal artery** is usually a branch of the middle meningeal, but it may arise from the first part of the internal maxillary artery. It enters the cranial cavity through the foramen ovale, and supplies the adjacent dura mater and the Gasserian ganglion.

The **middle meningeal artery,** as stated, is a branch of the first part of the internal maxillary artery. It is of large size, and enters the cranial cavity through the foramen spinosum in the sphenoid bone, after which it divides into two branches, anterior and posterior. The *anterior branch* passes forwards, outwards, and upwards in a groove on the upper surface of the great wing of the sphenoid bone to the inner aspect of the antero-inferior angle of the parietal bone, where there is a groove, or sometimes a short canal. The position of the middle meningeal artery at this level is ascertained by taking a point on the exterior of the skull 1½ inches behind the external angular process of the frontal bone, and 1½ inches above the zygomatic arch. From this point the artery ascends in a branching meningeal groove near the anterior border of the parietal bone, as high as the superior longitudinal sinus.

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In this part of its course it furnishes numerous branches forwards and backwards.

The *posterior branch* passes outwards and upwards on the squamous part of the temporal bone, and then on to the inner aspect of the inferior border of the parietal bone, where there is a meningeal groove about the centre. From this point it ascends in a branching groove as high as the superior longitudinal sinus, giving off branches forwards and backwards.

The distribution of the middle meningeal artery extends as high as the superior longitudinal sinus, forwards on to the frontal bone, and backwards on to the occipital bone. Besides supplying the dura mater and the inner table and diploë of the bones, the vessel furnishes the following branches: (1) *Gasserian* to the Gasserian ganglion; (2) a *petrosal branch*, which passes through the hiatus Fallopii to supply the facial nerve in the aqueduct of Fallopius, and anastomose with the stylo-mastoid branch of the posterior

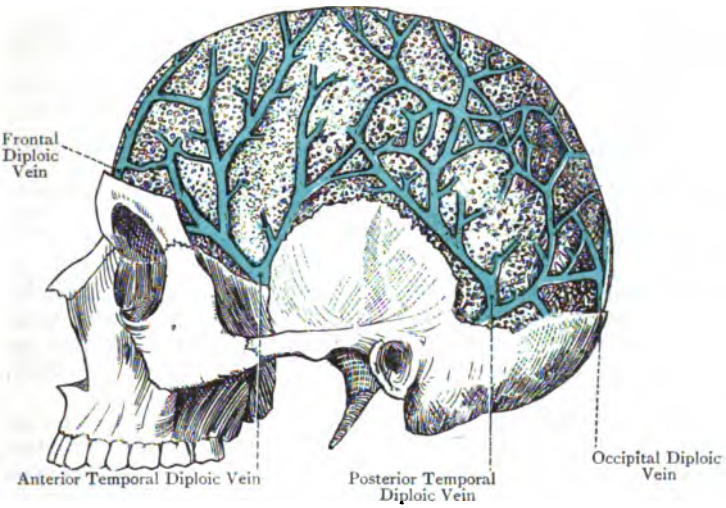

FIG. 590.—THE VEINS OF THE DIPLOË.

(The outer tables of the Cranial Bones have been removed).

auricular artery; and (3) an *orbital branch*, which enters the orbit through the sphenoidal fissure, and anastomoses with the ophthalmic artery.

The **meningeal branches of the ascending pharyngeal artery,** which is a branch of the external carotid, are three in number. One passes through the foramen lacerum medium into the middle fossa; another passes through the jugular foramen into the posterior fossa; and the third passes through the anterior condylar foramen, likewise into the posterior fossa.

The **posterior meningeal branch of the occipital artery** passes through the jugular foramen into the posterior fossa.

The **posterior meningeal branch of the vertebral artery** passes through the foramen magnum into the cerebellar fossa of the occipital bone.

Meningeal Veins.—The veins accompanying the middle meningeal artery are two in number. They pass through the foramen spinosum, and terminate in the pterygoid plexus of veins. The other meningeal veins are disposed in one of two ways. Some of them accompany the corresponding arteries and terminate in extracranial veins; whilst others terminate in the various intracranial venous sinuses, in part directly and in part through means of venous lacunæ.

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Veins of the Diploë.—These vessels are situated in the cancellated tissue between the outer and inner plates of the cranial bones, and are exposed after removal of the outer plate. They are destitute of valves, and are arranged in the form of a network, from which the blood is returned by four diploic veins on either side, namely, frontal, anterior temporal, posterior temporal, and occipital. These terminate partly in extracranial veins, and partly in the intracranial venous sinuses and meningeal veins.

The **frontal diploic vein** passes downwards, and escapes through an opening in the outer plate of the frontal bone at the supra-orbital notch, where it joins the communicating vein which passes between the supra-orbital and ophthalmic veins. It receives radicles from the frontal air-sinus of the same side.

The **anterior temporal diploic vein** is confined to the back part of the frontal and anterior part of the parietal regions, and descends to terminate in two ways. It partly joins one of the extracranial deep temporal veins, by passing through an opening in the outer plate of the great wing of the sphenoid, and in part it ends in a meningeal vein, or in the spheno-parietal, or, it may be, the cavernous, sinus.

The **posterior temporal diploic vein** is confined to the parietal region, and descends to the postero-inferior angle of the parietal bone, where it pierces the inner plate of that bone, and terminates in the lateral sinus.

The **occipital diploic vein** occupies the occipital region, and pierces the inner table of the occipital bone, to terminate in the lateral sinus.

Nerves of the Dura Mater.—The dura mater receives nerves from (1) the sympathetic plexuses which accompany the arteries; (2) the three divisions of the fifth cranial nerve; (3) the ganglion of the root of the pneumogastric nerve; and (4) the hypoglossal nerve.

Processes of the Dura Mater.—The dura mater, as stated, is composed of two layers—outer or periosteal, and inner or sustentacular. The processes are formed by the inner or sustentacular layer, and are four in number, namely, the falx cerebri, tentorium cerebelli, falx cerebelli, and diaphragma sellæ.

The **falx cerebri** is an extensive falciform process, which occupies the great longitudinal fissure of the cerebrum, where it lies between the two cerebral hemispheres. *Anteriorly* it is almost pointed, and is attached to the *crista galli* of the ethmoid bone. *Posteriorly* it is broad, and is attached to the upper surface of the tentorium cerebelli along the median line, the straight sinus being situated at the place of junction. The *superior border* is convex, and is attached in the median line to the frontal, parietal, and occipital bones, extending upon the latter bone only as low as the internal occipital protuberance. The superior longitudinal sinus is situated along this border. The *inferior border* is concave and free. It overhangs the upper surface of the corpus callosum, from which it is separated by a slight interval. The inferior longitudinal sinus is situated within this border. The *lateral surfaces* face the mesial surfaces of the cerebral hemispheres.

The **tentorium cerebelli** is an extensive crescentic sheet which covers the cerebellum. *Superiorly* it supports the posterior parts of the cerebral hemispheres, and is elevated along the median line, whence it slopes towards the attached borders. *Anteriorly* it presents a free, sharp, concave border, which forms, with the dorsum sellæ of the sphenoid bone anteriorly, an oval opening, called the *incisura tentorii*, within which the mesencephalon is

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placed. *Posteriorly* and *laterally* the tentorium cerebelli is convex, and is attached as follows, from behind forwards: (1) to the horizontal ridge on the inner surface of the tabular part of the occipital bone, where the process contains the lateral sinus; (2) to the inner aspect of the postero-inferior angle of the parietal bone, where the process also contains the lateral sinus; and (3) to the superior border of the petrous part of the temporal bone, where the process contains the superior petrosal sinus. Close to the apex of the *pars petrosa* the outer and anterior borders of the tentorium cerebelli cross, the outer border passing inwards to be attached to the posterior clinoid process of the sphenoid bone, and the anterior

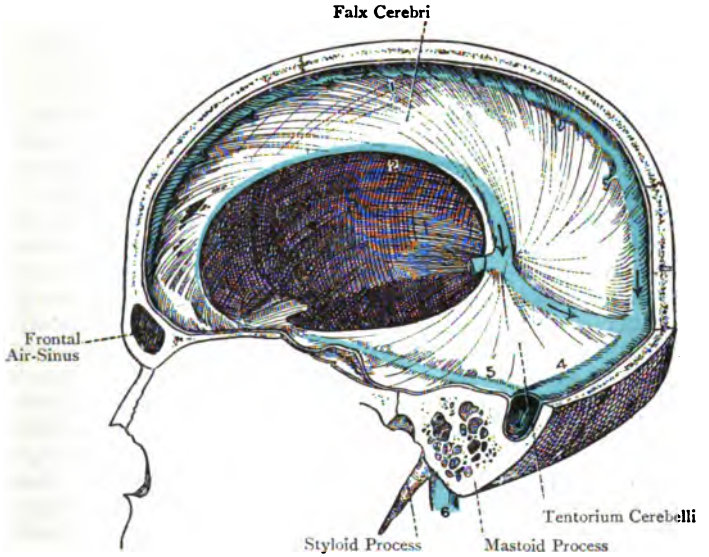

FIG. 591.—THE FALX CEREBRI, TENTORIUM CEREBELLI, AND VENOUS SINUSES OF THE DURA MATER (LEFT VIEW).

1. Superior Longitudinal Sinus
2. Inferior Longitudinal Sinus
3. Straight Sinus
4. Lateral Sinus
5. Superior Petrosal Sinus
6. Internal Jugular Vein

border passing forwards to be attached to the anterior clinoid process of that bone.

The **falx cerebelli** extends forwards into the posterior cerebellar notch, where it lies between the two cerebellar hemispheres. It is falciform in outline. *Superiorly* it is attached to the posterior part of the inferior surface of the tentorium cerebelli in the median line. *Posteriorly* it is attached to the internal occipital crest, and this portion bifurcates inferiorly, the two divisions being connected to the lateral margins of the vermiform fossa. Along this posterior

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attachment it contains the occipital sinus and its two divisions. *Anteriorly* it ends in a free border.

The **diaphragma sellæ** is a small circular fold, horizontally placed, which forms a roof for the sella turcica or pituitary fossa of the sphenoid bone, and almost entirely covers the pituitary body. At its centre there is a small opening for the passage of the infundibulum.

Venous Sinuses of the Dura Mater.—These are blood-channels or spaces situated between the two layers of the dura mater, and lined with endothelium. They are as follows :

Superior longitudinal sinus.	Spheno-parietal sinuses (two).
Inferior longitudinal sinus.	Circular sinus.
Straight sinus.	Superior petrosal sinuses (two).
Lateral sinuses (two).	Inferior petrosal sinuses (two).
Occipital sinus.	Transverse or basilar sinus.
Cavernous sinuses (two).	Petro-squamous sinuses (two).

The **superior longitudinal sinus** is situated in the median line within the superior convex border of the falx cerebri. It extends from the *crista galli* of the ethmoid bone to the internal occipital protuberance, where, as a rule, it turns sharply to the right, and opens into the right lateral sinus. It sometimes, however, turns to the left, and opens into the left lateral sinus. Its posterior extremity is dilated, and forms the **torcular Herophili,** which usually occupies a depression on the right side of the internal occipital protuberance, and is connected with the dilatation at the posterior extremity of the straight sinus by a transverse vessel. It increases in size as it passes backwards, and its shape is triangular, the base being directed towards the cranial vault. The apex is directed downwards, and in this region the sinus is crossed by a number of delicate fibrous bands, called the **chordæ Willisii.** Opening into the sinus on either side there are venous spaces, called **lacunæ laterales,** which are situated within the dura mater, and projecting into these lacunæ from below, or into the sinus itself, there are several Pacchionian bodies, covered by the endothelial lining. The sinus receives the superior cerebral veins and some of the meningeal veins of the falx cerebri. The former open into it from *behind forwards*, so that the blood-flow in these veins is opposed to the current of blood in the sinus, which is from before backwards.

The superior longitudinal sinus frequently communicates anteriorly with the veins of the roof of the nose through the *foramen cæcum*, and it communicates with the veins of the scalp by means of an emissary vein, which passes through the parietal foramen of each side, when that is present.

The **inferior longitudinal sinus** (vein) is of small size, and is situated in the lower free border of the falx cerebri over its posterior two-thirds. Its direction is backwards, and it opens into the front part of the straight sinus at the anterior margin of the tentorium cerebelli. It is circular, and increases in size as it passes

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backwards. Its tributaries are derived from the lower part of the falx cerebri, and from the adjacent parts of the mesial surfaces of the cerebral hemispheres.

The **straight sinus** is situated at the junction of the falx cerebri with the tentorium cerebelli, and is formed by the union between the inferior longitudinal sinus and the vena magna Galeni at the anterior margin of the tentorium. It is triangular, and increases in size from before backwards. Its course is downwards and backwards in the median line to the left side, as a rule, of the internal occipital protuberance, where it becomes slightly dilated, and is continued into the left lateral sinus. Its terminal dilatation is connected with the torcular Herophili by a transverse vessel. In those cases where the superior longitudinal sinus passes into the left lateral sinus, the straight sinus passes into the right lateral sinus. In addition to the inferior longitudinal sinus and the vena magna Galeni, the straight sinus receives some of the superior cerebellar veins and tributaries from the falx cerebri and tentorium cerebelli.

The **lateral sinuses** are two in number, right and left. Each sinus extends from the internal occipital protuberance to the postero-external compartment of the jugular foramen, through which it passes, to terminate in the bulb of the internal jugular vein. The sinus pursues a curved course. It passes outwards in the transverse groove on the inner surface of the tabular part of the occipital bone as far as the inner surface of the postero-inferior angle of the parietal bone. Here it ascends for a little in a groove, and, having described a sharp curve, it passes downwards and inwards in the sigmoid groove on the inner surface of the mastoid portion of the temporal bone. Finally, it turns forwards in the groove on the upper surface of the jugular process of the occipital bone to the jugular foramen. As far as the postero-inferior angle of the parietal bone the lateral sinus is contained within the attached border of the tentorium cerebelli, and, just before leaving this, it receives the superior petrosal sinus. The right lateral sinus is, as a rule, formed by the superior longitudinal sinus, and, in these circumstances, is larger than the left, which is usually formed by the straight sinus. The reverse, however, may be the case. As stated, the torcular Herophili and the terminal dilatation of the straight sinus are connected by a transverse branch.

The lateral sinus of each side, in addition to the superior petrosal sinus, receives tributaries from the posterior part of the cerebrum and the superior and inferior surfaces of the cerebellum. It also receives the posterior temporal and occipital diploic veins, and the petro-squamous sinus, when that sinus is present. Near its termination it communicates with the marginal sinus of the same side. The sinus communicates with extracranial veins by means of two large emissary veins, posterior condylar and mastoid, which pass through the corresponding foramina. These foramina,

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however, being inconstant, the emissary veins referred to are sometimes awanting.

The **course of the lateral sinus** may be indicated, on the exterior, by drawing a line horizontally outwards from the external occipital protuberance to the base of the mastoid process, on a level with the auricular point, and then downwards in a curved manner to

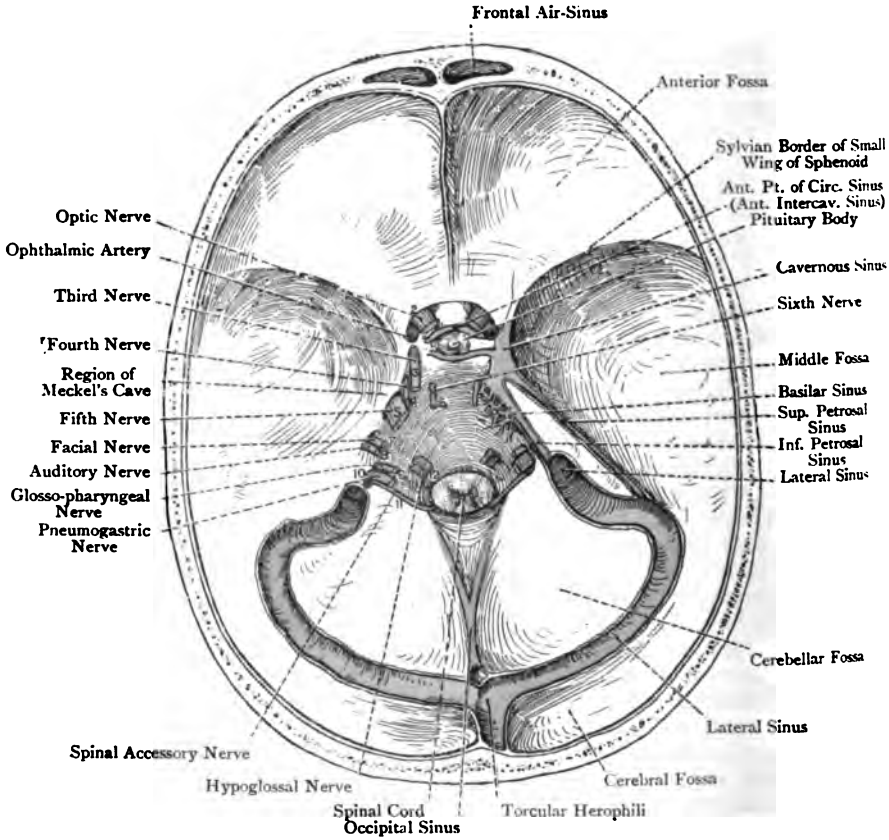

FIG. 592.—THE INTERNAL BASE OF THE SKULL, SHOWING THE CRANIAL NERVES AND VENOUS SINUSES.

the tip of the mastoid process. This latter part of the line is situated in the groove between the auricle and the mastoid process.

The **occipital sinus** is situated within the falx cerebelli along its attachment to the internal occipital crest. It is of small size, and is formed inferiorly by the union of the two *marginal sinuses* (inferior occipital) which lie on either side of the vermiform fossa and foramen

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magnum, where they communicate with the posterior intraspinal veins and the terminal part of each lateral sinus. Superiorly it opens into the torcular Herophili. In certain cases the marginal or inferior occipital sinuses remain separate, and then each opens into the corresponding lateral sinus. The occipital sinus receives tributaries from the falx cerebelli and the inferior surface of the cerebellum, and it establishes a communication between the commencement and termination of the lateral sinuses.

The **cavernous sinuses** are two in number—right and left—and are so named because the interior of each is broken up by fibrous filaments, which impart to it a reticular appearance. Each sinus is situated on the side of the body of the sphenoid bone, and extends from the inner extremity of the sphenoidal fissure to the apex of the petrous part of the temporal bone. Anteriorly it receives the ophthalmic vein, or veins, from the orbit, and posteriorly it terminates by dividing into the superior and inferior petrosal sinuses. In addition to the ophthalmic vein, or veins, the cavernous sinus receives the spheno-parietal sinus and some of the inferior cerebral veins. It communicates with the angular vein of the face through the superior ophthalmic vein; with its fellow of the opposite side through the circular sinus; with the lateral sinus by the superior petrosal sinus; with the internal jugular vein by the inferior petrosal sinus; with the pterygoid plexus through the inferior ophthalmic vein, and by an emissary vein which passes through the foramen ovale, or through the foramen Vesalii; and with the pharyngeal plexus by an emissary vein which passes through the foramen lacerum medium. The internal carotid artery, with the cavernous sympathetic plexus, lies in contact with the inner wall of the sinus, and the sixth cranial nerve is close to the outer side of the artery. In connection with the outer wall of the sinus there are the third, fourth, and ophthalmic and superior maxillary divisions of the fifth, cranial nerves.

The **spheno-parietal sinuses** are two in number—right and left. Each is of small size, and is situated on the inferior surface of the small wing of the sphenoid bone. It generally commences in connection with the anterior temporal diploic vein, and terminates in the anterior part of the cavernous sinus.

The **circular sinus** surrounds the pituitary body in the pituitary fossa. It is composed of two transverse sinuses—anterior intercavernous and posterior intercavernous—which lie in front of and behind the pituitary body, and establish communications between the cavernous sinuses.

The **superior petrosal sinus** is situated along the superior border of the petrous part of the temporal bone, and lies within the attached margin of the tentorium cerebelli. It commences at the back part of the cavernous sinus, and, having passed outwards and backwards, it opens into the lateral sinus as that is about to enter the sigmoid groove of the *pars mastoidea*. It receives tributaries from the cerebellum and tympanum.

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The **inferior petrosal sinus** occupies the groove at the junction of the basilar process of the occipital bone with the petrous part of the temporal bone. It commences at the back part of the cavernous sinus, and, passing backwards and slightly outwards, it leaves the cranial cavity through the antero-internal compartment of the jugular foramen, to terminate in the bulb of the internal jugular vein. It receives tributaries from the inferior surface of the cerebellum, and from the internal ear.

The **transverse** or **basilar sinus** is really a plexus of veins, situated within the dura mater over the basilar process of the occipital bone, and extending as low as the anterior margin of the foramen magnum, where it communicates with the anterior intraspinal veins. It connects the anterior ends of the inferior petrosal sinuses with each other.

The **petro-squamous sinuses** are two in number—right and left—and are situated, on either side, along the junction of the petrous and squamous parts of the temporal bone. The direction of each is backwards, and it opens into the lateral sinus as that is entering the sigmoid fossa of the *pars mastoidea*.

Each petro-squamous sinus represents the continuation of the lateral sinus, in early life, to terminate in the primitive jugular vein. Sometimes there are no traces of these petro-squamous sinuses.

Emissary Veins.—These are vessels which pass through foramina in the cranial wall, and serve to establish communications between the intracranial venous sinuses and the extracranial veins. The principal emissary veins are as follows: mastoid, nasal, posterior condylar, parietal, and occipital. In addition to these there are emissary veins, which pass through (1) the foramen ovale, (2) the foramen Vesalii (when present), and (3) the foramen lacerum medium.

The *lateral sinus*, in many cases, has two emissary veins, mastoid and posterior condylar.

The **mastoid emissary vein** is of large size. It passes through the mastoid foramen, and usually opens into the posterior jugular vein, but it may open into the posterior auricular vein.

The **posterior condylar emissary vein** passes through the posterior condylar foramen, and opens into the suboccipital plexus, from which the blood is carried away by the vertebral and deep cervical veins.

The mastoid and posterior condylar veins are not constant.

The *superior longitudinal sinus* has three emissary veins—nasal, parietal, and occipital.

The **nasal emissary vein** passes through the foramen cæcum, in front of the crista galli of the ethmoid bone, and it establishes a communication between the superior longitudinal sinus and the veins of the roof of the nose.

The **parietal emissary vein** passes through the parietal foramen, and opens into the occipital plexus, or into radicles of the superficial temporal vein.

The **occipital emissary vein** passes from the torcular Herophili to the occipital plexus, being transmitted through a minute foramen which pierces the external occipital protuberance.

The nasal, parietal, and occipital emissary veins are inconstant.

As previously stated, the **cavernous sinus** communicates with (1) the angular vein of the face, (2) the pterygoid plexus, and (3) the pharyngeal plexus. The **marginal** or **inferior occipital sinus** communicates with the posterior intraspinal veins, and the **transverse** or **basilar sinus** communicates with the anterior intraspinal veins.

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Arachnoid Membrane.

This is a very delicate membrane which loosely surrounds the encephalon, and is situated between the dura mater and pia mater. It does not dip into the fissures, except in the case of the great longitudinal fissure, its general course being over the gyri and other eminences and depressions of the encephalon. It is conspicuous at the base of the encephalon in the region of the inter-peduncular space, pons Varolii, and medulla oblongata. Its outer surface is practically in close contact with the inner surface of the dura mater, the extremely slight interval containing a very little lubricating serous fluid, and being known as the **subdural space.** Between the arachnoid and the pia mater there is the interval known as the subarachnoid space. The membrane furnishes sheaths to the various cranial nerves.

Subarachnoid Space.—This space, as stated, is situated between the arachnoid and the pia mater. It is crossed by delicate trabeculæ of connective tissue, which pass between the two membranes in a reticular manner. The meshes of this reticulum contain the cerebro-spinal fluid.

The subarachnoid space communicates with the ventricles of the brain by means of five openings. Three of these communicate with the fourth ventricle, namely, the foramen of Magendie, and the foramina of Key and Retzius, the former being situated in the median line of the roof of the ventricle a little above the calamus scriptorius, and the latter being situated each in the roof of the lateral recess of the ventricle. The other two openings communicate with the descending cornua of the lateral ventricles, each being situated at the extremity of the corresponding cornu. In some situations—as, for example, over the gyri—the arachnoid and pia mater are in close contact; but in other localities the two membranes are more or less widely separated by intervals, called **cisternæ.** These are principally three in number, namely, the cisterna magna, cisterna pontis, and cisterna basalis.

The **cisterna magna** lies between the posterior part of the inferior surface of the cerebellum and the medulla oblongata. It is of large size, the arachnoid, which here passes from cerebellum to medulla, being widely separated from the pia mater. It is continuous through the foramen magnum with the posterior part of the subarachnoid space of the spinal cord.

The **cisterna pontis** is situated on the ventral aspect of the pons Varolii. Inferiorly it is continuous with the anterior part of the subarachnoid space of the spinal cord, and in the region of the medulla oblongata it is continuous posteriorly with the cisterna magna. It contains the basilar artery.

The **cisterna basalis** is situated in front of the pons Varolii, in which situation the arachnoid extends over the interpeduncular space from one temporal lobe to the other. It contains the arteries which form the circle of Willis. This cisterna is prolonged outwards

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on each side into the stem of the fissure of Sylvius, each of these prolongations containing the middle cerebral artery. Anteriorly it extends in front of the optic commissure into the great longitudinal fissure over the upper surface of the corpus callosum, this prolongation containing the anterior cerebral arteries.

The **subarachnoid fluid** can be drained away in two directions. It can enter the lymph-spaces of the cranial nerves upon which the arachnoid is prolonged outwards in the form of sheaths; and it can enter the lacunæ laterales through the intervention of the Pacchionian bodies, and from these lacunæ it can make its way into the superior longitudinal sinus.

Structure of the Arachnoid Membrane.—The arachnoid consists of delicate bundles of fibrous tissue, which interlace with one another. Its external and internal surfaces are covered by endothelial cells.

The nerves of the arachnoid are derived from the sympathetic system.

Pacchionian Bodies.—These are small fleshy-looking bodies which are situated along the course of the superior longitudinal sinus, into which some of them project. They are also met with in connection with other sinuses, *e.g.*, the lateral and straight sinuses. Each Pacchionian body is a localized projection of the arachnoid membrane, with which it is connected by a narrow pedicle. As stated, some Pacchionian bodies project into the superior longitudinal sinus; others project from below into the lacunæ laterales. In all cases the bodies carry before them the lining of the sinus. Superficially the bodies give rise to the Pacchionian depressions on the internal surface of the parietal bone near the superior border. Each Pacchionian body, as stated, is a localized projection of the arachnoid membrane (enlarged villus—Luschka). It contains a prolongation of the subarachnoid space and reticulum. This is surrounded by a prolongation of the arachnoid membrane, and external to this is the endothelial lining of the sinus or of the lacuna. The Pacchionian bodies constitute channels through which the subarachnoid fluid can be drained away from the subarachnoid space into the lacunæ laterales, and thence into the superior longitudinal sinus, as well as into the other sinuses, *e.g.*, the lateral and straight sinuses. They are quite rudimentary in early life, and are most conspicuous in advanced life.

Pia Mater.

The pia mater is the most internal covering of the encephalon. It is a very vascular membrane, which invests, and is closely adherent to, the entire surface. From its internal surface delicate processes pass into the cerebral substance, which represent the minute bloodvessels, surrounded by pia-matral sheaths. The pia mater not only invests the external surface, but also dips into the sulci, and covers the opposed surfaces of the gyri. It also furnishes

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sheaths to the various cranial nerves, which blend with their perineurium. It gives rise to two web-like expansions, namely, the tela choroidea inferior and tela choroidea superior.

The **tela choroidea inferior** is situated in the lower part of the roof of the fourth ventricle, and from it are derived the choroid plexuses of that ventricle. The **tela choroidea superior,** or *velum interpositum,* is an invagination of the pia mater through the transverse fissure beneath the splenium of the corpus callosum. It lies underneath the body of the fornix, and its deep surface is covered by the ependymal lining of the third ventricle, the latter forming the roof of that cavity. The tela choroidea superior furnishes the choroid plexuses of the two lateral and third ventricles.

The pia mater of the encephalon differs from the pia mater of the spinal cord in being thinner and less adherent to the nervous substance. The greater thinness is due to the fact that it is destitute of the outer layer which characterizes the spinal pia mater.

Structure.—The pia mater of the encephalon consists of a single layer of areolar tissue, which contains a great many small bloodvessels, these being derived from the larger vessels, lying in the subarachnoid space.

The Cranial Nerves.

The cranial nerves are arranged in twelve pairs. They have received numerical names according to the order in which they leave the cranial cavity from before backwards, and they are also known by functional names. The different pairs of nerves are as follows, in order from before backwards:

First, or **olfactory.**
Second, or **optic.**
Third, or **oculo-motor.**
Fourth, or **trochlear (pathetic).**
Fifth, or **trigeminal (trifacial).**
Sixth, or **abducent.**
Seventh, or **facial.**
Eighth, or **auditory.**
Ninth, or **glosso-pharyngeal.**
Tenth, or **pneumogastric (vagus).**
Eleventh, or **spinal accessory.**
Twelfth, or **hypoglossal.**

The cranial nerves are connected to certain parts of the encephalon, and these connections constitute their *superficial* or *apparent origins.* The fibres, however, can be traced to certain collections of grey matter, which are called **nuclei.** From the deep positions occupied by these nuclei they constitute the *deep origins* of the nerves.

First or Olfactory Nerve.—This nerve is a complex structure, and consists of (1) the olfactory lobe, and (2) the olfactory filaments or nerves, which are about twenty in number.

The **olfactory lobe** has been already described (see p. 1300).

The **olfactory nerves** are non-medullated. They arise as the axons of the olfactory cells of the olfactory mucous membrane of the nasal fossa, and enter the cranial cavity through the foramina of one half of the cribriform plate of the ethmoid bone. Thereafter they enter the grey matter on the ventral or inferior aspect of the olfactory bulb, and terminate in arborizations which intermingle

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with the arborizations formed by the dendrites of the mitral cells, situated in the granular layer of the bulb (see p. 1343).

The olfactory nerve is the nerve of smell.

Second or Optic Nerve.—This nerve arises from the brain by means of the optic tract, the deep connections of which have been already described (p. 1327). Each **optic tract** passes forwards and inwards to the **optic commissure** or **chiasma,** which is situated in

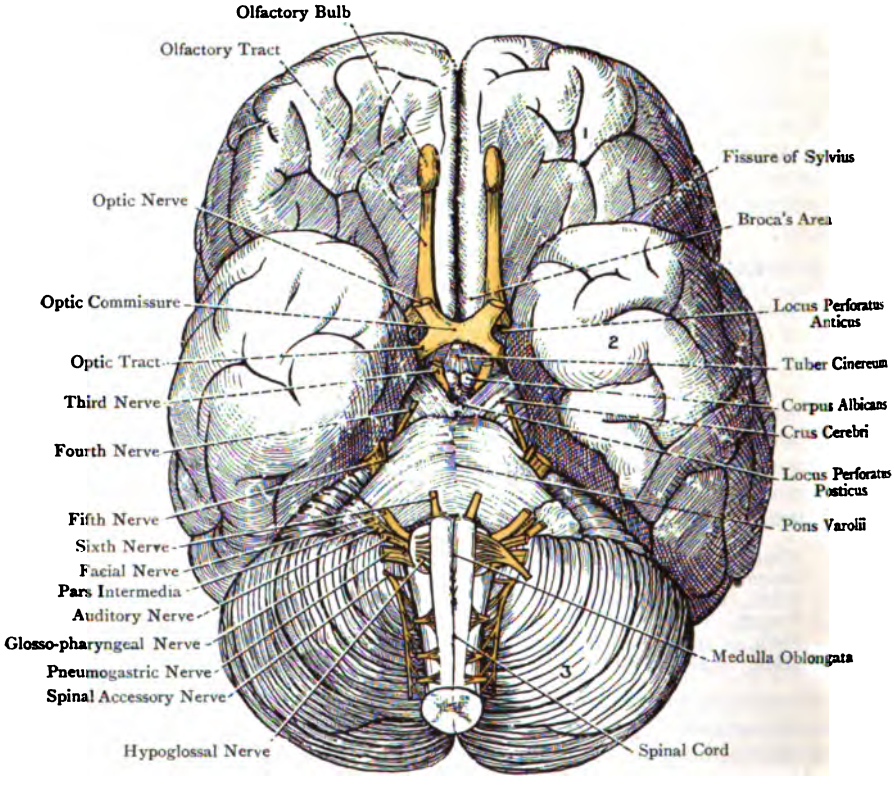

FIG. 539.—THE BASE OF THE ENCEPHALON, AND THE CRANIAL NERVES.

1, Frontal Lobe (Orbital Surface); 2, Temporal Lobe; 3, Cerebellum.

front of the interpeduncular space. The **optic nerve** of each side arises from the anterior part of the optic commissure. It courses forwards and outwards to the optic foramen, through which it passes into the orbit, piercing the dura mater, and receiving a sheath from it, as well as from the arachnoid membrane. Having reached the back part of the eyeball, it pierces the sclerotic and choroid coats $\frac{1}{8}$ inch to the nasal or inner side of the axis

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of the eyeball, and terminates in an expansion which forms the most internal layer of the retina, called the nerve-fibre or optic layer.

The optic nerve is the nerve of sight.

Third or Oculo-motor Nerve.—The fibres of this nerve arise from the *oculo-motor nucleus*, which is situated in the grey matter of the ventral aspect (floor) of the aqueduct of Sylvius, on a level with

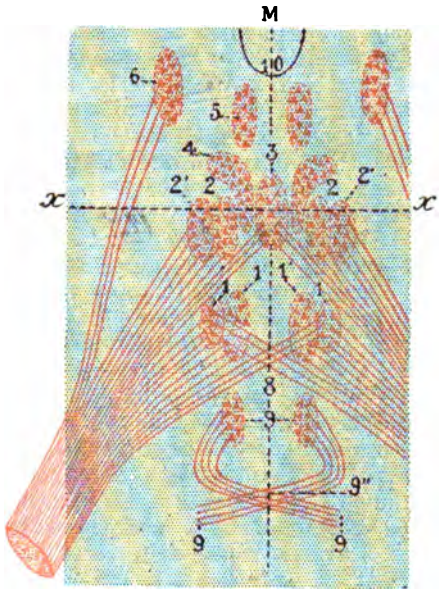

FIG. 594.—SCHEME SHOWING THE DIFFERENT CELL-GROUPS WHICH CONSTITUTE, ACCORDING TO PERLIA, THE NUCLEUS OF ORIGIN OF THE THIRD CRANIAL OR OCULO-MOTOR NERVE (L. TESTUT'S 'ANATOMIE HUMAINE').

1. Posterior Dorsal Nucleus
1'. Posterior Ventral Nucleus
2. Anterior Dorsal Nucleus
2'. Anterior Ventral Nucleus
3. Central Nucleus
4. Nucleus of Edinger and Westphal
5. Antero-internal Nucleus
6. Antero-external Nucleus
7. Trunk of Oculo-Motor Nerve
8. Crossed Fibres
9. Fourth Cranial Nerve
9'. Nucleus of Origin of Fourth Nerve
9''. Intercrossing of Fourth Cranial Nerves
10. Third Ventricle
M. Middle Line

the upper quadrigeminal body, and extends superiorly, for a short distance, on to the lateral wall of the third ventricle. The nucleus is intimately related to the posterior longitudinal bundle, through means of which it is connected with the trochlear and abducent nuclei. All three nuclei receive collaterals from the posterior longitudinal bundle; and in this manner a functional association between these nuclei is maintained, and harmonious action is insured on the part of the muscles which are supplied by the nerves

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arising from them. It consists of several groups of cells. As many as seven groups are ascribed to each oculo-motor nucleus by Perlia, which correspond to the seven muscles supplied by the oculo-motor nerve, and are disposed symmetrically. In addition to these, there is a mesially-placed group, the cells of which furnish fibres to both oculo-motor nerves. The fibres which arise from the individual groups of each nucleus are regarded as supplying particular orbital muscles. Certain of the oculo-motor fibres of one side arise from the nucleus of the opposite side, the fibres from either side decussating at the median line. Moreover, each oculo-motor nerve is said to receive fibres from the abducent nucleus of the opposite side, which ascend in the posterior longitudinal bundle and cross to the other side.

Two views are entertained in regard to the nerve supply of the internal rectus muscle. According to one view, the muscle of one side is supplied by those fibres which have crossed from the oculo-motor nucleus of the opposite side. The other view is that the muscle of one side is supplied by those fibres which have crossed from the abducent nucleus of the opposite side. According to this latter view the nerve-fibres which supply the external rectus muscle of one side and those which supply the internal rectus muscle of the opposite side arise from the same nucleus, namely, the abducent nucleus, and *vice versâ*.

Fibres are conveyed by the posterior longitudinal bundle from the oculo-motor nucleus to the facial nerve, and thence to the orbicularis palpebrarum and corrugator supercilii muscles.

Course of the Fibres of the Third Nerve.—The fibres pass forwards from their origin through the tegmentum, the red nucleus, and the inner portion of the substantia nigra, and thereafter make their superficial appearance at the oculo-motor sulcus on the inner aspect of the crus cerebri.

The third or oculo-motor nerve supplies the following seven muscles: the levator palpebræ superioris; the superior, inferior and internal recti; the inferior oblique; the sphincter pupillæ; and the ciliary muscle.

Fourth, Trochlear, or Pathetic Nerve.—The fibres of this nerve arise from the *trochlear nucleus*, which is situated in the grey matter of the ventral aspect (floor) of the aqueduct of Sylvius, on a level with the upper part of the lower quadrigeminal body. The nucleus is intimately related to the posterior longitudinal bundle, through means of which it is connected with the oculo-motor nucleus.

The fibres are at first directed outwards and backwards, and then downwards and inwards to the upper part of the superior medullary velum, or valve of Vieussens, which they enter. Here the nerve crosses to the opposite side, decussating with its fellow, after which it emerges from the upper end of the superior medullary velum, close below the lower quadrigeminal body, and by the side of the *frenulum veli*. Thereafter the nerve turns outwards over the superior peduncle of the cerebellum, and is then directed forwards

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round the outer aspect of the crus cerebri, between which and the temporal lobe it makes its superficial appearance.

The fourth nerve supplies the superior oblique muscle of the eyeball.

Fifth, Trifacial, or Trigeminal Nerve.—The fifth nerve resembles a spinal nerve in having two roots—sensory and motor, the former having the Gasserian ganglion.

Sensory Root.—The fibres of this root arise from the cells of the Gasserian ganglion, which resemble those of a spinal ganglion. After entering the pons Varolii the root divides into two bundles, the fibres of which terminate in connection with two terminal nuclei, called the upper sensory nucleus and the lower sensory nucleus. The *upper sensory nucleus* is situated in the outer portion of the dorsal part of the pons, where it lies close to the outer side of the pontine (motor) nucleus, and it receives a few of the sensory fibres. The *lower sensory nucleus* is represented by a column of cells which is continuous with the substantia gelatinosa Rolandi of the spinal cord. To reach the lower nucleus the most of the sensory fibres pass downwards through the pons and medulla oblongata as low as the level of the second cervical spinal nerve. These fibres constitute the **spinal** or **ascending root** of the fifth nerve, and they terminate at intervals in the lower sensory nucleus.

Motor Root.—The fibres of this root are derived from two nuclei, pontine and mesencephalic. The *pontine nucleus* is situated in the outer portion of the dorsal part of the pons, close to the inner side of the upper sensory nucleus, and beneath the floor of the pontine portion of the fourth ventricle. The *mesencephalic nucleus* is situated in the grey matter on the lateral aspect of the aqueduct of Sylvius. The fibres which arise from this latter nucleus constitute the **descending, mesencephalic,** or **Sylvian root** of the fifth nerve. It enters the pons, and reinforces the fibres which arise from the pontine (motor) root.

The sensory and motor roots emerge close together from the lateral aspect of the ventral surface of the pons Varolii, the motor root lying above, and slightly internal to, the sensory root.

The fifth nerve has a wide *sensory* distribution to (1) the front part of the cranium, (2) the face, (3) the auricle and external auditory meatus, (4) the eye, (5) the nose, (6) the mouth and teeth, and (7) the anterior two-thirds of the tongue. Its *motor* distribution is to the muscles of mastication.

Sixth or Abducent Nerve.—The fibres of this nerve arise from the *abducent nucleus*, which is situated in the dorsal part of the pons Varolii, close to the median line. It lies above the striæ acusticæ on the floor of the fourth ventricle, subjacent to the eminentia teres. The fibres emerge from the inner part of the nucleus, and pass through the lower part of the pons in a forward and slightly downward and outward direction to the point where the nerve makes its superficial appearance, namely, the lower border of the pons, just external to the pyramid of the medulla oblongata.

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Some of the fibres from the abducent nucleus enter the posterior longitudinal bundle, and ascend in it to the third or oculo-motor nerve of the opposite side, and thence to the internal rectus muscle of that side. The fibres which supply the external rectus muscle of one side and those which supply the internal rectus muscle of the opposite side may, therefore, be regarded as arising from the same nucleus, namely, the abducent nucleus. This nucleus is also regarded as receiving fibres from the pyramidal tract of the opposite side.

The sixth nerve supplies the external rectus muscle of the eyeball.

Seventh or Facial Nerve.—The facial nerve is composed of two parts. One of these consists of efferent or motor fibres, and is known as the facial nerve proper. The other part, of small size, consists of afferent or sensory fibres, and is called the pars intermedia of Wrisberg. The **facial nerve proper** arises from the *facial nucleus*, which is situated deeply in the dorsal part of the lower portion of the pons Varolii. The fibres of the nerve pursue an intricate course before appearing superficially. They at first pass backwards and inwards to the floor of the fourth ventricle. Here they turn upwards, lying close to the median line in the form of a single bundle. The nerve then makes a sharp bend outwards, and passes forwards through the pons in a downward and outward direction to its place of emergence. In its course within the pons the nerve is intimately related to the dorsal aspect of the abducent nucleus.

The facial nerve is said to receive fibres from the oculo-motor nucleus through the posterior longitudinal bundle, by means of which it supplies the orbicularis palpebrarum and corrugator supercilii muscles.

The facial nucleus receives fibres from the pyramidal tract of the opposite side, and also fibres from the corpus trapezoides in the pons, the latter fibres establishing a connection between the facial and auditory nerves.

The **pars intermedia of Wrisberg,** or sensory portion of the facial nerve, arises from the cells of the *geniculate ganglion* on the nerve in the aqueduct of Fallopius. The cells of this ganglion, like those of the spinal ganglia, are unipolar. The single process of each cell divides into two branches—central and peripheral. The *central branches* give rise to the pars intermedia of Wrisberg, which emerges from the aqueduct of Fallopius and the internal auditory meatus. At the lower border of the pons Varolii the pars intermedia passes into the medulla oblongata, and its fibres terminate in connection with the cells of the grey matter around the upper part of the **fasciculus solitarius.** From this connection the pars intermedia of Wrisberg is closely associated with the glosso-pharyngeal nerve. The *peripheral branches* of the unipolar cells of the geniculate ganglion give rise to the chorda tympani nerve.

The facial nerve proper makes its superficial appearance at the lower border of the pons Varolii, in front of the restiform body;

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and the pars intermedia of Wrisberg appears external to the preceding, between it and the auditory nerve.

The facial nerve is distributed to the muscles of the scalp and face; the muscles of the auricle; the stapedius, stylo-hyoid, and posterior belly of the digastric; and to the fore part of the tongue.

Eighth or Auditory Nerve.—The auditory nerve has two roots—cochlear or lateral, and vestibular or mesial. The cochlear root courses round the outer side of the restiform body, its fibres being continued through the cochlear nucleus into the striæ acusticæ on

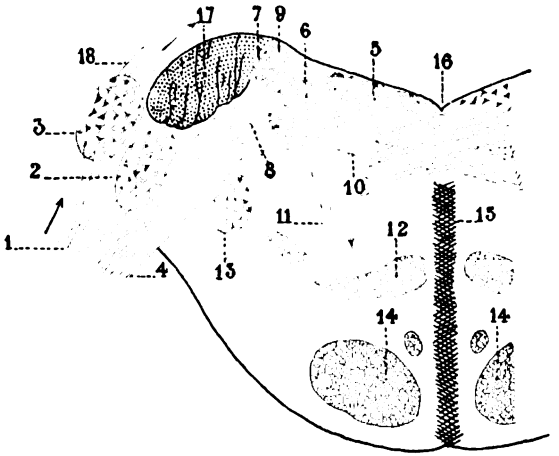

FIG. 595.—TERMINAL NUCLEI OF THE VESTIBULAR NERVE, WITH THEIR SUPERIOR CONNECTIONS (SCHEMATIC) (L. TESTUT'S 'ANATOMIE HUMAINE').

1. Cochlear Root, with its Two Nuclei
2. Accessory Nucleus
3. Lateral Nucleus, or Tuberculum Acusticum
4. Vestibular Root
5. Internal Dorsal Nucleus
6. External Dorsal Nucleus, or Nucleus of Deiters
7. Nucleus of Bechterew
8. Inferior or Descending Root of Auditory Nerve
9. Ascending Cerebellar Fibres
10. Fibres passing to Raphé
11. Oblique Fibres
12. Fillet
13. Inferior Sensory Root of Fifth Cranial Nerve
14. Pyramidal Fibres
15. Raphé
16. Fourth Ventricle
17. Inferior Peduncle of Cerebellum (Restiform Body)
18. Origin of Striæ Acusticæ

the floor of the fourth ventricle. The vestibular root passes backwards between the olivary and restiform bodies.

Cochlear Root.—The fibres of this root terminate in two nuclei—ventral and lateral. The *ventral cochlear nucleus* is situated in front of the restiform body, where it lies between the cochlear and vestibular roots. The *lateral cochlear nucleus* (*tuberculum acusticum*) is situated on the outer side of the restiform body.

Vestibular Root.—Three terminal nuclei are associated with the fibres of this root, namely, (1) the dorsal or principal nucleus;

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(2) the internal nucleus, or nucleus of the descending root; and (3) the external nucleus, or nucleus of Deiters.

The *dorsal* or *principal nucleus* is situated in the floor of the fourth ventricle, underneath the acustic area, and therefore belongs to both the pontine and bulbar portions of the floor. The striæ acusticæ cross it superficially. The *internal nucleus*, or *nucleus of the descending root*, is situated in the bulbar part of the floor, and receives those fibres of the vestibular root which descend through the lower part of the pons into the medulla. The *external nucleus*, or *nucleus of Deiters*, is associated with the descending root. Superiorly it is situated in the lateral wall of the fourth ventricle, and its upper and outer part is known as the *nucleus of Bechterew*. The external nucleus receives a great many of the fibres of the vestibular root.

The cochlear and vestibular roots have certain central connections, which will now be briefly stated.

Cochlear Root.—This is the nerve of hearing. As stated, its fibres terminate in connection with the ventral cochlear nucleus and the lateral cochlear nucleus (tuberculum acusticum). The axons of the cells of the ventral cochlear nucleus give rise to the corpus trapezoides, and the axons of the cells of the lateral cochlear nucleus give rise to the striæ acusticæ. The fibres of the corpus trapezoides cross to the opposite side, after which they ascend as the **lateral fillet.** In this course the fibres are interrupted by three groups of cells, namely, (1) those of the superior olive of their own side; (2) those of the superior olive of the side to which they cross; and (3) those of the nucleus of the lateral fillet. The lateral fillet ultimately terminates in the lower quadrigeminal body and corpus geniculatum internum of its own side.

The *striæ acusticæ* arise as the axons of the cells of the lateral cochlear nucleus. They wind round the posterior aspect of the restiform body, and then cross the floor of the fourth ventricle. On reaching the median line they sink into the adjacent portions of the medulla and pons, and then cross to the opposite side, where they become part of the lateral fillet of that side. The lateral fillet is therefore composed of: (1) the fibres of the corpus trapezoides, and (2) the striæ acusticæ, both of the opposite side, and it serves to connect the ventral and lateral cochlear nuclei with the lower quadrigeminal body and corpus geniculatum internum of the opposite side. The two cochlear nuclei are also to a certain extent connected with the lower quadrigeminal body of their own side, but not with the corpus geniculatum internum of their own side. Finally, the corpus geniculatum internum is connected with the cortex of the superior temporal gyrus.

The cochlear root is connected with the oculo-motor, trochlear, and abducent nuclei by fibres which pass to these nuclei from the superior olive.

Vestibular Root.—This is the nerve of equilibrium. The dorsal nucleus and external nucleus, or nucleus of Deiters, are connected with the *superior vermis* of the cerebellum by means of the direct

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sensory cerebellar tract (Edinger), the fibres of which, for the most part, come from the cerebellar hemisphere of the opposite side.

The auditory nerve makes its superficial appearance at the lower border of the pons Varolii in front of the restiform body, where it lies on the outer side of the facial nerve, the pars intermedia of Wrisberg intervening between the two.

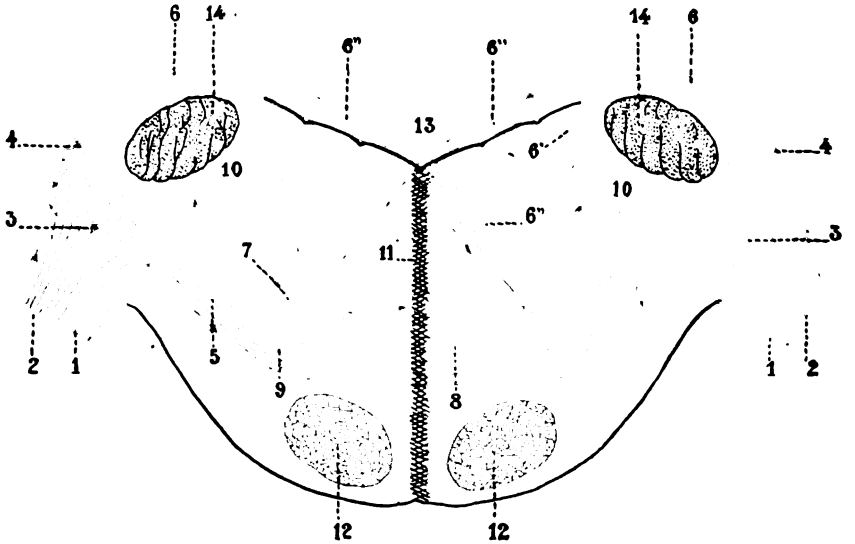

FIG. 596.—TERMINAL NUCLEI OF THE COCHLEAR NERVE, WITH THEIR SUPERIOR CONNECTIONS (SCHEMATIC) (L. TESTUT'S 'ANATOMIE HUMAINE').

(The vestibular root and its terminal nuclei, with the efferent fibres of these latter, have been suppressed. In order not to obscure the trapezoid body, the efferent fibres of the terminal nuclei of the right side have been in a great part of their extent resected. The trapezoid body is consequently composed of only half of its fibres—namely, those which come from the left).

1. Vestibular Root of Auditory Nerve
2. Cochlear Root
3. Accessory Nucleus of Auditory Nerve
4. Lateral Nucleus, or Tuberculum Acusticum
5. Efferent Fibres of Accessory Nucleus
6. Efferent Fibres of Lateral Nucleus, forming the Striæ Acusticæ
6'. Direct Fibres of the Striæ Acusticæ going to the Superior Olivary Body of the same side
6''. Crossed Fibres of the Striæ Acusticæ going to the Superior Olivary Body of the opposite side
7. Superior Olivary Body
8. Corpus Trapezoides
9. Trapezoid Nucleus
10. Lateral Fillet
11. Raphé
12. Pyramidal Tract
13. Fourth Ventricle
14. Inferior Peduncle of Cerebellum (Restiform Body)

Ninth or Glosso-pharyngeal Nerve.—This nerve consists of afferent and efferent fibres. The **afferent fibres** (sensory) arise from the cells of the *jugular and petrous ganglia*, which resemble those of the Gasserian and spinal ganglia. Having entered the medulla oblongata, they terminate in two ways. (1) Some of them

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end in arborizations around the cells of the *vagal nucleus*, which lies underneath the **trigonum vagi** in the lower part of the floor of the fourth ventricle. (2) Other fibres enter the strand, called the **fasciculus solitarius**, in which they descend to terminate in connection with the cells of the surrounding grey matter. The **efferent fibres** (motor) arise from the cells of the *accessory vagal nucleus*, or *nucleus ambiguus*.

The fasciculi of the glosso-pharyngeal nerve make their superficial appearance in the postero-lateral sulcus of the medulla oblongata, between the olivary and restiform bodies, immediately below the facial nerve.

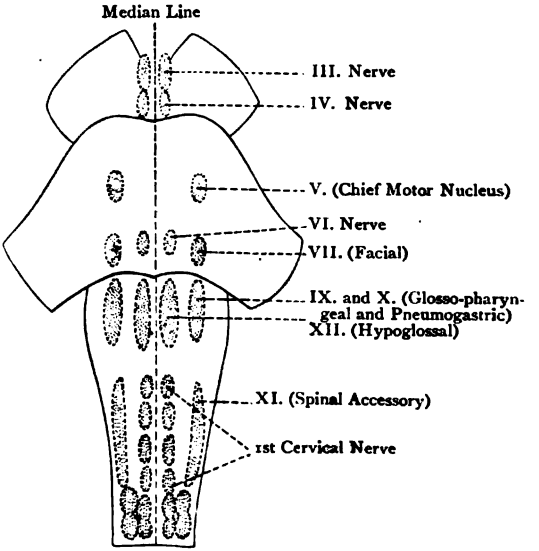

FIG. 597.—SCHEME SHOWING THE CONTINUATION OF THE GREY MATTER OF THE SPINAL CORD INTO THE MEDULLA OBLONGATA, PONS VAROLII, AND CRURA CEREBRI (POIRIER).

(The separation into two columns on either side and the breaking up of these into Cranial Motor Nuclei are indicated).

The glosso-pharyngeal nerve is distributed to the tongue and pharynx, as well as to the stylo-pharyngeus muscle.

Tenth, Pneumogastric, or Vagus Nerve.—This nerve consists of afferent and efferent fibres. The **afferent fibres** (sensory) arise from the cells of the *ganglion of the root* and *the ganglion of the trunk*, which resemble those of the Gasserian and spinal ganglia. Having entered the medulla oblongata, they terminate in two ways. (1) Some of them end in arborizations around the cells of the vagal nucleus, which, as stated, lies underneath the **trigonum**

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vagi in the lower part of the floor of the fourth ventricle. (2) Other fibres enter the strand, called the **fasciculus solitarius,** in which they descend to terminate in connection with the cells of the surrounding grey matter. The **efferent fibres** (motor) arise from the cells of the *accessory vagal nucleus*, or *nucleus ambiguus*.

The fasciculi of the pneumogastric nerve make their superficial appearance in the postero-lateral sulcus of the medulla oblongata, in front of the restiform body, and below the fasciculi of the glosso-pharyngeal nerve.

The pneumogastric nerve is distributed to the pharynx, œsophagus, and stomach, and to the organs of respiration, this distribution being sensory.

In connection with the deep origins of the glosso-pharyngeal and pneumogastric nerves, the following structures fall to be described, namely, (1) the vagal nucleus, (2) the nucleus ambiguus, and (3) the fasciculus solitarius. The **vagal nucleus** is intimately related to the hypoglossal nucleus, and, like it, lies partly in the *open part* and partly in the *closed part* of the medulla oblongata. In the open part it lies underneath the **trigonum vagi,** external to the hypoglossal nucleus, and extends as high as the striæ acusticæ. In the closed part of the medulla it descends very nearly as low as a point just above the decussation of the pryamids, and here it lies behind the hypoglossal nucleus.

According to some authorities, the vagal nucleus is a nucleus of *termination*, receiving afferent or sensory fibres from the glosso-pharyngeal and pneumogastric nerves, which terminate in arborizations around its cells. According to other authorities, it is a nucleus of *origin*, furnishing efferent or motor fibres to these two nerves.

The **nucleus ambiguus,** or **accessory vagal nucleus,** is usually regarded as the source of the efferent or motor-fibres of the glosso-pharyngeal and pneumogastric nerves. Its cells are continuous with the anterior cornual cells of the spinal cord, and are arranged in the form of a strand, which lies in the *formatio reticularis grisea* of the medulla oblongata.

The **fasciculus solitarius** is composed of longitudinal fibres, which represent the afferent fibres of the glosso-pharyngeal and pneumogastric nerves. It occupies a deeper position than the vagal nucleus, and extends throughout the entire length of the medulla oblongata. The fasciculus is surrounded by grey matter, containing small nerve-cells, in connection with which its constituent fibres terminate.

Eleventh or Spinal Accessory Nerve.—This nerve consists of two portions—spinal and accessory or bulbar.

The **spinal portion** arises by several roots from cells in the anterior grey cornu of the spinal cord, which are situated posterior to the lateral group of anterior cornual cells, and extend as low as the fifth cervical nerve. The roots emerge at intervals from the lateral column of the cord, and join to form the spinal portion, which ascends to the foramen magnum, lying between the ligamentum

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denticulatum and the posterior roots of the adjacent spinal nerves.

The **accessory** or **bulbar portion** arises in the medulla oblongata or bulb from cells which are associated with the nucleus ambiguus. The fasciculi of the spinal accessory nerve make their appearance on the medulla oblongata below the fasciculi of the pneumogastric nerve, and they continue to emerge from the lateral column of the spinal cord as low as the level of the fifth cervical nerve.

The **spinal portion** of the spinal accessory nerve is distributed to the trapezius and sterno-cleido-mastoid muscles. The **accessory** or **bulbar portion** (*motor*), through the pneumogastric to which it is accessory, is distributed to (1) the muscles of the soft palate; (2) the constrictor muscles of the pharynx; (3) the muscular fibres of the œsophagus, stomach, and intestinal canal; (4) the muscular tissue of the organs of respiration; and (5) the muscular tissue of the heart, the fibres to the cardiac muscular tissue being *inhibitory*.

Twelfth or Hypoglossal Nerve.—The fibres of this nerve arise from the *hypoglossal nucleus*, which is situated in the medulla oblongata. The upper part of this nucleus extends as high as the striæ acusticæ, and corresponds to the area on the lower half of the floor of the fourth ventricle, which is called the **trigonum hypoglossi.** The lower part of the nucleus is contained within the closed part of the medulla, and extends as low as a point above the decussation of the pyramids. The nerve-fasciculi pass through the medulla in a dorso-ventral direction, lying between its anterior and lateral areæ, and between the formatio reticularis alba and formatio reticularis grisea.

The fasciculi of the hypoglossal nerve make their superficial appearance in the antero-lateral sulcus of the medulla oblongata between the pyramid and the olivary body.

The hypoglossal nerve is distributed to the muscles of the tongue.

Cranio-cerebral Topography.

The **bregma,** or point of junction of the sagittal and coronal sutures, corresponds to the centre of a line connecting the two auricular points (the centre of the orifice of the meatus auditorius externus).

The **lambda,** or meeting of the sagittal and lambdoidal sutures, is situated about 2¾ inches above the inion, or external occipital protuberance.

The **pterion,** or region of the spheno-parietal suture, is situated about 1½ inches behind the external angular process of the frontal bone, and about 1¾ inches above the zygomatic arch.

The **asterion,** or point where the parieto-mastoid, occipito-mastoid, and lambdoid sutures meet, is situated about 2 inches behind the auricular point, very nearly in line with the upper border of the zygomatic arch.

The **sagittal line** represents the line which connects the nasion, or meeting of the two fronto-nasal sutures, with the inion.

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The **sagittal suture** corresponds to that part of the sagittal line which extends from the lambda to the bregma.

The **coronal suture** is indicated on either side by a line extending from the bregma to the pterion.

The **lambdoid suture** (occipito-parietal) corresponds to a line extending from the lambda to the asterion.

The **squamo-parietal suture,** and its continuation backwards as the parieto-mastoid suture, are indicated by a curved line, with the convexity upwards, extending from the pterion to the asterion, the highest part of the curve being about 2 inches above the zygomatic arch.

The **superior longitudinal sinus** corresponds to a line drawn from the glabella to the inion, or external occipital protuberance. For the most part it occupies the median line, but, as it grooves the upper portion of the tabular part of the occipital bone, it deviates to one side, most commonly the right side.

The **torcular Herophili** is usually situated on the right side of the inion.

The **occipital sinus** corresponds to a line drawn downwards from the inion.

The **lateral sinus** is indicated by a curved line drawn from the inion outwards and forwards to the base of the mastoid process of the temporal bone on a level with the upper margin of the orifice of the meatus auditorius externus. From this point the line passes in a curved manner downwards and inwards over the back of the mastoid process towards its tip, as far as a point about $\frac{1}{4}$ inch below the level of the lower margin of the orifice of the meatus auditorius externus. Beyond this point the line passes forwards to the position of the jugular foramen. A ready guide to the position of the sigmoid or mastoid portion of the lateral sinus is the line of reflection of the skin from the auricle on to the head. The lateral sinus may be readily opened at a point 1 inch behind the meatus auditorius externus, on a level with the upper margin of its orifice.

The large **anterior division of the middle meningeal artery,** as it lies in the groove, or, it may be, short canal, on the internal aspect of the antero-inferior angle of the parietal bone, is indicated by taking a point $1\frac{1}{8}$ inches behind the external angular process of the frontal bone, and $1\frac{1}{2}$ inches above the zygomatic arch. From this point it ascends almost vertically towards the sagittal suture, lying about $\frac{1}{2}$ inch behind the coronal suture.

The small **posterior division of the middle meningeal artery** lies about 2 inches behind the anterior division.

The **lower level of the cerebral hemisphere** corresponds approximately to the following line: commencing at a point immediately below the glabella, the line passes outwards in a curved manner, with the convexity upwards, about $\frac{1}{2}$ inch above the supra-orbital arch. It then crosses the temporal ridge of the frontal bone from $\frac{1}{4}$ to $\frac{1}{2}$ inch above the base of the external angular process, after

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which it passes backwards and slightly downwards to a point about 1 inch behind the external angular process. The line now passes downwards and backwards to the upper border of the zygomatic arch about its centre. It then passes backwards along the upper border of the arch, lying about ¼ inch above the upper margin of the orifice of the meatus auditorius externus. Thereafter it crosses the supramastoid crest, and follows the line of the lateral sinus to the inion.

The **Sylvian point,** which represents the division of the fissure of

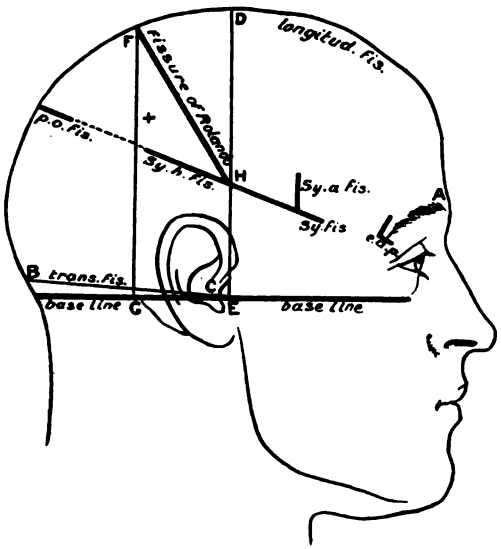

FIG. 598.—DIAGRAM SHOWING THE RELATIONS OF THE CHIEF CEREBRAL FISSURES TO THE EXTERIOR OF THE HEAD (REID).

A. Glabella
B. Inion
C. Auricular Point
E. Pre-auricular Point
F. Superior Rolandic Point
G. Posterior Border of Root of Mastoid Process
H. Inferior Rolandic Point
B.C. Transverse Fissure
D.E., F.G. Reid's Perpendicular Lines
Sy. Fis. Sylvian Fissure
Sy.a. Fis. Anterior Limb of Sylvian Fissure
Sy.h. Fis. Posterior Horizontal Limb of Sylvian Fissure
p.o. Fis. External Parieto-occipital Fissure
+ Parietal Eminence

Sylvius into its three limbs, anterior, ascending, and posterior, is situated on the outer surface of the cerebral hemisphere, and corresponds to the pterion, which, as stated, is situated about 1½ inches behind the external angular process of the frontal bone, and about 1¾ inches above the zygomatic arch. The *anterior limb* of the Sylvian fissure passes horizontally forwards, and the *ascending limb* upwards and slightly forwards, from the Sylvian point, each for about ½ inch. The *posterior limb* corresponds to the **Sylvian line,** which extends from the Sylvian point backwards and slightly upwards

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for about 3 inches, and then vertically upwards for about ½ inch to a point ¾ inch below the parietal eminence.

Fissure of Rolando.—The **superior Rolandic point,** which indicates the upper end of the fissure of Rolando, is situated about 2 inches behind the bregma, or about ½ inch behind the centre of the sagittal line, which connects the nasion and the inion.

The **inferior Rolandic point,** which indicates the lower end of the fissure of Rolando, is situated about 2 inches behind and a little above the level of the external angular process, and about

FIG. 599.—THE OUTER SURFACE OF THE RIGHT CEREBRAL HEMISPHERE, SHOWING THE RELATIONS OF ITS GYRI AND FISSURES TO THE EXTERIOR OF THE CRANIUM (FROM A PREPARATION MADE BY THE AUTHOR).

1 inch behind the coronal suture. A line connecting the superior and inferior Rolandic points indicates the fissure of Rolando, which is about 3½ inches in length. This line is called the **Rolandic line,** and it should present two curves, an upper, concave forwards, and a lower, convex forwards. If sufficiently prolonged, the Rolandic line would correspond to about the centre of the zygomatic arch.

Another way to indicate the fissure of Rolando is to utilise **Reid's base line,** which represents a line drawn backwards from the centre of the infra-orbital margin through the auricular point (the centre

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of the orifice of the meatus auditorius externus). A point in this line situated in the depression between the tragus of the auricle and the condyle of the inferior maxilla is called the **pre-auricular point.** Two lines are drawn upwards, perpendicular to Reid's base line, one from the pre-auricular point, and the other from the posterior border of the mastoid process close to its root. These two lines, together with the sagittal and Sylvian lines, enclose a quadrilateral area, and the diagonal of this area which connects its postero-superior and antero-inferior angles represents the fissure of Rolando.

The angle which the Rolandic line forms with the sagittal line is called the **Rolandic angle,** and is from 65° to 70°.

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THE EYE

THE eyeball is almost spherical. It consists of the segments of two spheres, namely, a large posterior or sclerotic segment, which is opaque, and a small anterior or corneal segment, which is transparent. The sclerotic segment forms five-sixths of the eyeball, and the corneal segment forms one-sixth. The centre of the

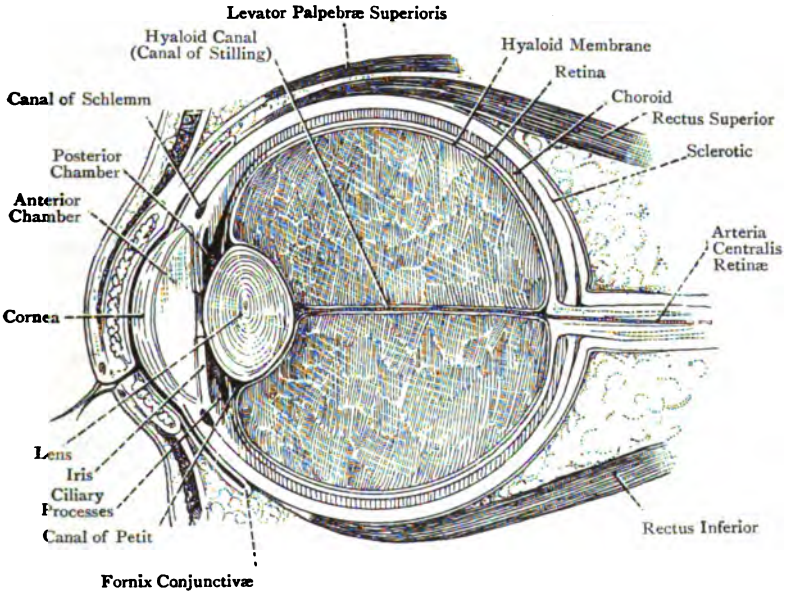

FIG. 600.—VERTICAL SAGITTAL SECTION OF THE EYE AND ITS APPENDAGES (HIRSCHFELD AND LEVEILLÉ).

corneal segment is called the **anterior pole,** and the centre of the sclerotic segment is known as the **posterior pole.** The sagittal (antero-posterior) axis, or **axis of vision,** of the eyeball is represented by a line connecting the anterior and posterior poles. The **equator** is represented by a line encircling the eyeball opposite the centre of the axis of vision, the diameter of the circle being

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about 1 inch. The plane of this circle would therefore divide the eyeball into two halves—an anterior half, consisting of the corneal segment and the front part of the sclerotic segment, and a posterior half, consisting of the back part of the sclerotic segment. The **meridian** is represented by a line encircling the eyeball at right angles to the equator, and passing through the anterior and posterior poles.

Posteriorly the eyeball receives the optic nerve, which pierces the sclerotic coat at a point about $\frac{1}{8}$ inch to the inner side of, and about $\frac{1}{24}$ inch below, the posterior pole.

The eyeball is composed of three coats, concentrically arranged, as follows: (1) an *external coat*, consisting of an opaque part, called the **sclerotic**, and a transparent part, called the **cornea**; (2) a *middle coat*, which is vascular, pigmented, and muscular, and consists of (*a*) a posterior part, called the **choroid coat,** (*b*) an anterior part, called the **iris**, and (*c*) an intermediate part, representing the **ciliary body**; and (3) an *internal coat*, called the **retina.**

These three coats enclose a cavity which contains the *refracting media*, these being three in number, as follows: (1) a fluid, called the **aqueous humour,** which lies between the cornea and the crystalline lens, where it occupies the *anterior* and *posterior chambers*, into which this region is divided by the iris; (2) a solid body, called the **crystalline lens,** which lies behind the aqueous humour; and (3) a soft gelatinous body, called the **vitreous body,** which occupies the large space behind the crystalline lens.

Coats of the Eyeball.	**Refracting Media.**
External = sclerotic and cornea.	Aqueous humour.
Middle = choroid, ciliary body, and iris.	Crystalline lens.
Internal = retina.	Vitreous body.

External Coat.

Sclerotic Coat.—The sclerotic (white of the eye) is a strong white fibrous coat of great density, which surrounds the posterior five-sixths of the eyeball, and maintains the shape of the organ. Anteriorly it unites, and becomes continuous, with the cornea, which it slightly overlaps. The junction of the two is indicated by a slight groove, called the *sulcus scleræ*, and the union is known as the *corneo-scleral junction*. Posteriorly the sclerotic is pierced by the optic nerve, this part being known as the *optic entrance*. It is situated, as stated, at a point about $\frac{1}{8}$ inch to the inner side of, and about $\frac{1}{24}$ inch below, the posterior pole of the eyeball. The part of the sclerotic corresponding to the optic entrance is pierced by a number of openings for the passage of the fasciculi of the optic nerve, and is hence called the *lamina cribrosa*.

Around the optic entrance there are numerous minute openings for the ciliary vessels and nerves, and in this situation the dura-matral sheath of the optic nerve blends with the sclerotic. About midway between the optic entrance and the corneo-scleral junction

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the sclerotic is pierced by about four openings for the passage of the *venæ vorticosæ*.

The sclerotic is thickest posteriorly around the optic entrance. It is also thick near the corneo-scleral junction, where it gives insertion to the recti muscles, from the tendinous expansions of which it receives accessions of fibres.

The *outer surface* of the sclerotic is covered by a membranous investment, called the **capsule of Tenon,** and between the two there is the **perisclerotic lymph-space** or **Tenon's space,** which is broken up into a reticulum by processes of connective tissue which pass between the capsule of Tenon and the sclerotic. This space communicates with the subdural and subarachnoid spaces. The *inner surface* is of a dark brown colour, and presents grooves for the ciliary vessels and nerves. It is lined with connective tissue containing pigment cells, this layer being called the **lamina fusca.** Processes from this layer pass to be attached to the choroid coat, and these processes, together with vessels and nerves, traverse an interval, which represents the **perichoroidal lymph-space.** This space communicates with the perisclerotic lymph-space through the vascular openings in the sclerotic. *Anteriorly* the sclerotic blends with the cornea at the corneo-scleral junction, the sclerotic slightly overlapping the cornea. *Posteriorly*, around the optic entrance the sclerotic blends with the dura-matral sheath of the optic nerve.

Structure.—The sclerotic is composed of fibrous tissue, mixed with elastic fibres, and it contains many connective-tissue corpuscles. The fibres are arranged in bundles, which are disposed longitudinally and transversely, and interlace with one another. The connective-tissue corpuscles occupy spaces between the fibres, which may be regarded as lymph-spaces.

Arteries.—These are the short ciliary group of posterior ciliary arteries, and the anterior ciliary arteries, which are branches of the ophthalmic artery. The vessels belonging to the former group are disposed in the form of capillary networks; whilst the vessels derived from the latter form a ring near the corneo-scleral junction beneath the conjunctiva, to which ring they converge in the substance of the sclerotic.

The sclerotic **veins** open into the anterior ciliary veins, and into the *venæ vorticosæ*.

Nerve-supply.—The ciliary nerves.

The capsule of Tenon will be found described on p. 1075.

Cornea.—The cornea is the transparent part of the external coat of the eyeball, of which it forms the anterior sixth, and it serves to transmit light. It is almost circular, its transverse measurement being slightly greater than the vertical. At its circumference it is continuous with the sclerotic, by which it is slightly overlapped. The *anterior surface* is convex. The *posterior surface* is concave, and forms the anterior boundary of the anterior chamber of the eye.

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Structure.—The cornea consists of five layers, which are as follows, from before backwards :

1. The conjunctival epithelium.
2. The anterior elastic lamina.
3. The substantia propria.
4. The posterior elastic lamina.
5. A layer of endothelium.

The **conjunctival epithelium** is of the stratified variety, there being not less than six strata of cells, and it is continuous with the epithelium which covers the free surface of the conjunctiva. The

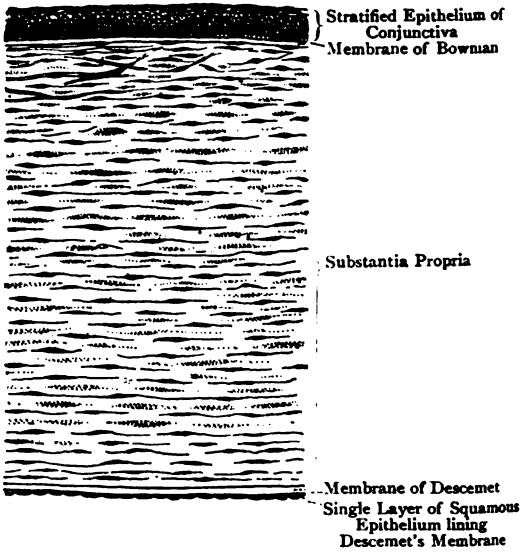
Stratified Epithelium of Conjunctiva
Membrane of Bowman
Substantia Propria
Membrane of Descemet
Single Layer of Squamous Epithelium lining Descemet's Membrane

FIG. 601.—VERTICAL SECTION OF THE CORNEA (MAGNIFIED).

cells of the deepest stratum are columnar ; succeeding to these there are layers of polygonal cells ; and these in turn are overlaid by layers of squamous cells.

The **anterior elastic lamina** (Bowman) is probably of the same nature as the fibrous portion of the substantia propria. It is closely connected with the substantia propria, is thin, and contains no corpuscles.

The **substantia propria** is composed of modified connective tissue, arranged in bundles which form superimposed laminæ. These laminæ amount in number to about sixty. The fibres of alternate laminæ cross each other at right angles, and at the circumference of the cornea they are continuous with the fibres of the sclerotic.

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The successive laminæ are connected by cement substance, and within this substance there are branched spaces, called the **corneal spaces** or **lacunæ,** which communicate with each other by very delicate canaliculi. Each of these spaces contains a nucleated connective-tissue corpuscle, called the **corneal corpuscle.** These corpuscles, like the spaces which they occupy, are branched, and the offsets of adjacent corpuscles communicate with one another. As seen in vertical sections of the cornea the corpuscles are spindle-shaped, but in horizontal sections they appear flattened out, and give off their branches.

The **posterior elastic lamina,** or **membrane of Descemet** (*membrane of Demours*), covers the posterior surface of the substantia propria. It is thicker than the anterior elastic lamina, and is composed of an elastic homogeneous membrane, which is very brittle. When stripped from the substantia propria it comes away in shreds, and these curl up at their ends in such a manner that the anterior or attached surface of each shred is turned inwards. At the circumference of the cornea the posterior elastic lamina becomes broken up into fibres. The most posterior of these fibres pass in a radiating and reticular manner into the iris, and they form the ligamentum pectinatum iridis, the intervals between the fibres of which represent the spaces of Fontana.

The **layer of endothelium** lines the posterior surface of the posterior elastic lamina, and consists of one stratum of cells. It is continued over the front of the iris, and into the spaces of Fontana.

The cornea in the adult is non-vascular, except at the circumference, in which situation there are the conjunctival and sclerotic capillaries, which terminate in loops. Being destitute of blood-vessels, the nourishment of the cornea is maintained by the flow of lymph through its substance.

Nerve-supply.—The nerves are derived from the ciliary nerves, and are very numerous. They enter the anterior part of the sclerotic, and form a plexus around the corneo-scleral junction. Offsets from this plexus enter the cornea, and form what is known as the *plexus annularis*. From this plexus delicate offsets are given off, which traverse the substance of the cornea and pass through the anterior elastic lamina. They then give rise to a fine plexus upon the surface of that lamina, called the *subepithelial plexus*. From this plexus, in turn, minute fibrils are given off, which pass amongst the cells of the conjunctival epithelium, and almost reach the surface, forming an **intra-epithelial plexus.**

Ligamentum Pectinatum Iridis.—As stated, the posterior elastic lamina at its circumference breaks up into fibres. The most posterior fibres, which pass in a radiating and recticular manner into the iris, constitute the ligamentum pectinatum iridis, and they are covered by a prolongation of the endothelial layer of the cornea.

Spaces of Fontana.—These spaces represent the irregular intervals which lie between the radiating and reticular fibres of the ligamentum pectinatum iridis. They are lined by a prolongation

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of the endothelial layer of the cornea, and they communicate *internally* with the anterior chamber and the lymph spaces within the iris, and *externally* with the canal of Schlemm.

Canal of Schlemm (canal of Fontana, *sinus circularis iridis*, or *sinus venosus scleræ*).—This canal is situated deeply in the sclerotic, close to the corneo-scleral junction. It communicates *internally* with the anterior chamber through means of the spaces of Fontana, and with the veins of the iris, and *externally* with the veins of the sclerotic.

Middle Coat.

1. **Choroid Coat.**—This is a very vascular, deeply pigmented tunic of a dark brown colour, which lies between the sclerotic and the retina. It extends over the posterior five-sixths of the eyeball,

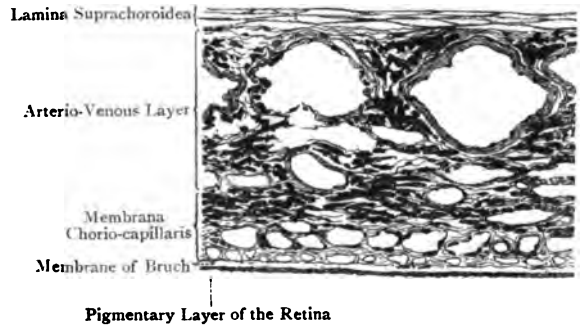

FIG. 602.—VERTICAL SECTION OF THE CHOROID COAT.

(The Pigmentary Layer of the Retina is also shown).

and reaches as far forwards as the ora serrata of the retina. Anteriorly it is connected with the circumference of the iris, and posteriorly it is pierced by the optic nerve. Its *outer surface* is connected to the inner surface of the sclerotic by means of the lamina fusca and its processes, as well as by vessels and nerves which cross the perichoroidal lymph-space. Its *inner surface* is in contact with the pigmentary layer of the retina.

Structure.—The choroid coat consists of connective tissue, bloodvessels, and branched pigment cells. It is composed of three layers, which are as follows, from without inwards: (1) the lamina suprachoroidea; (2) the choroid proper; and (3) the lamina basalis, or membrane of Bruch.

The **lamina suprachoroidea** is composed of delicate, non-vascular lamellæ, each of which is made up of elastic fibres, arranged in a reticular manner, and of branched pigment cells.

The **choroid proper** consists principally of bloodvessels and pig-

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ment-cells, supported by connective tissue. The bloodvessels are arranged partly as arteries and veins, and partly as capillaries. The choroid proper is therefore composed of two layers, namely, external or lamina vasculosa, and internal or lamina chorio-capillaris.

The **lamina vasculosa** (arterio-venous layer) is composed of (1) branches of the short ciliary group of the posterior ciliary arteries, which pass forwards before they turn inwards to terminate in capillaries; and (2) veins, which form the chief part of the lamina vasculosa, and are called the **venæ vorticosæ.** These veins are very closely set, and are arranged in a whorled manner. They ultimately converge and form about four vessels, which pierce the sclerotic nearly midway between the optic entrance and the corneo-scleral junction, at points equally distant from each other. Scattered throughout the lamina vasculosa there are branched pigment-cells.

The **lamina chorio-capillaris,** or **tunica Ruyschiana,** is composed of a plexus of capillary bloodvessels, the arteries leading to it being derived from the short ciliary arteries.

The lamina vasculosa and lamina chorio-capillaris are connected by fine elastic fibres, which form what is known as the *stratum intermedium.*

The **lamina basalis,** or **membrane of Bruch,** is situated on the inner surface of the lamina chorio-capillaris, which it separates from the pigmentary layer of the retina. It is a very delicate membrane, without any very definite structure.

Tapetum.—This is present in certain animals. It lies between the lamina vasculosa and the lamina chorio-capillaris in the stratum intermedium, and it gives rise to a rainbow-like appearance. In some animals it is fibrous in structure, and in others cellular.

2. **Ciliary Body.**—The ciliary body, as stated, connects the anterior part of the choroid to the circumference of the iris. It is composed of (1) the orbicularis ciliaris, (2) the ciliary processes, and (3) the ciliary muscle.

The **orbicularis ciliaris** is a narrow zone which lies immediately in front of the anterior part of the choroid, with which it is continuous. It presents plications which are radially disposed, and it separates the ciliary processes from the ora serrata of the retina.

The **ciliary processes,** which are about seventy in number, are projections or infoldings of the anterior part of the choroid, and consist of the choroid proper and the membrane of Bruch. They constitute a series of rays, arranged in a circular manner, and converge as they pass inwards and forwards to the periphery of the crystalline lens on its anterior aspect. They are somewhat conical in outline. Their free extremities, which are round and prominent, lie behind the circumference of the iris upon the anterior aspect of the periphery of the crystalline lens. Their attached extremities are connected with the orbicularis ciliaris.

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Anteriorly they are related to the posterior chamber of the eyeball at its circumference. Posteriorly they rest upon the zonule of Zinn, the folds of which fit closely in between them.

Structure.—The ciliary processes are similar in structure to the choroid, but the pigment-cells are not so numerous. On their deep or posterior surfaces the processes are covered by the **pars ciliaris retinæ,** which is prolonged from the pigmentary layer of the retina, and is continuous with the pars iridica retinæ (uvea) on the posterior surface of the iris.

The arteries of the ciliary processes are derived from those of the anterior part of the choroid, and from the anterior ciliary arteries. The veins pass to those of the choroid.

Ciliary Muscle.—This muscle is composed of unstriped fibres. It forms a greyish-white ring, about $\frac{1}{10}$ inch broad, which is

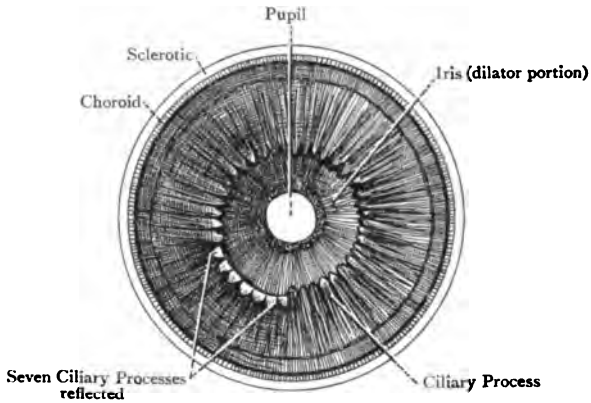

FIG. 603.—THE IRIS AND CILIARY PROCESSES (POSTERIOR VIEW) (HIRSCHFELD AND LEVEILLÉ).

situated at the anterior part of the choroid, opposite the ciliary processes. The fibres are arranged in two sets—radial and circular. The *radial fibres* arise from the deep surface of the sclerotic, close to the corneo-scleral junction, and behind the canal of Schlemm. From this origin they pass backwards in a radiating manner, and are inserted into the orbicularis ciliaris and the attached ends of the ciliary processes. The *circular fibres* form a ring around the circumference of the iris, internal to the radial fibres.

The ciliary muscle is supplied by the ciliary nerves, which are branches of the ciliary ganglion.

Action.—The ciliary muscle is the muscle of *accommodation*, and adjusts the eye to the vision of near objects. When it contracts it draws forwards the choroid and the ciliary processes ; the suspensory ligament of the crystalline lens is thereby relaxed ; and, as a consequence, the anterior surface of the lens is rendered convex.

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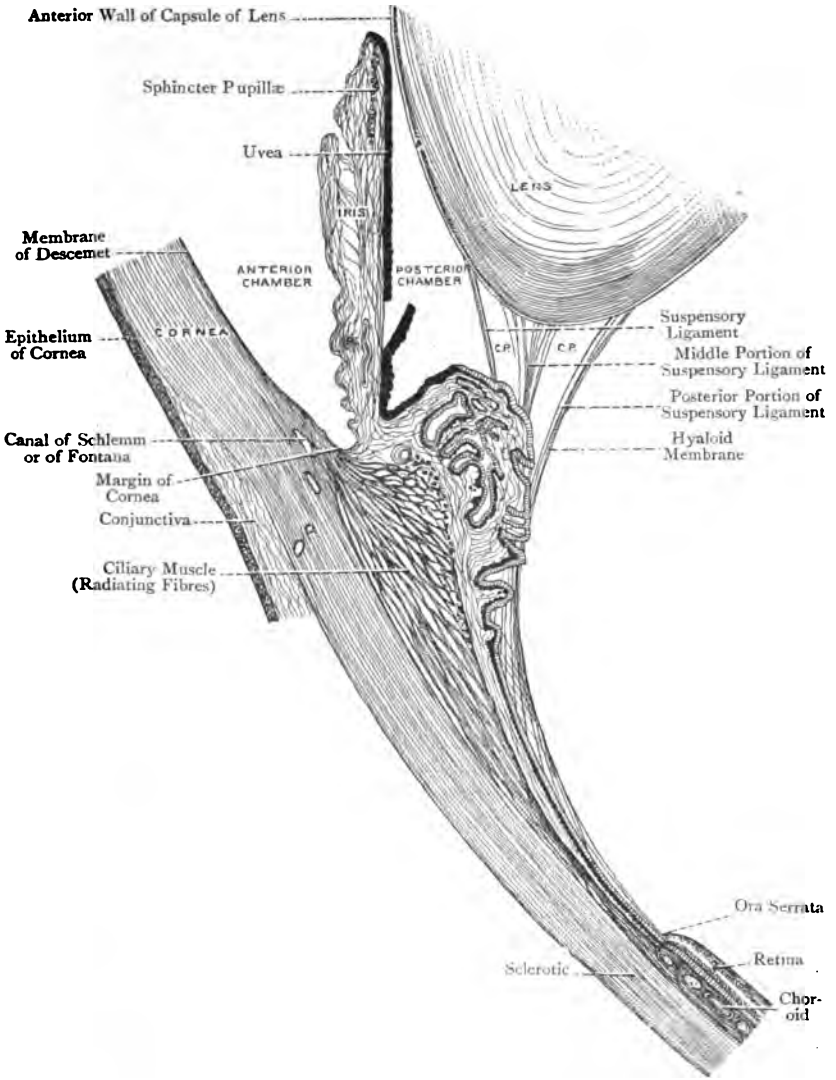

FIG. 604.—MERIDIONAL SECTION THROUGH THE ANTERIOR PORTION OF THE EYE (MAGNIFIED 16 × 1) (FUCHS).

C.P., C.P., Canal of Petit.

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The circular fibres of the ciliary muscle are well developed in cases of hypermetropia, but are deficient in cases of myopia.

3. **Iris.**—The iris forms the anterior part of the middle coat of the eyeball. It is a coloured contractile curtain, which is suspended in the aqueous humour between the cornea and the crystalline lens. It is perforated by an almost circular aperture, called the **pupil,** which is situated slightly to the nasal or inner side of its centre, and serves for the transmission of light. The margin which surrounds the pupil is known as the *pupillary margin.* Its circumference is continuous with the ciliary body, and is connected with the posterior elastic lamina of the cornea by means of the ligamentum pectinatum iridis. The circumference is known as the *ciliary margin.* The surfaces of the iris are anterior and posterior. The *anterior surface* is directed towards the cornea. Its colour varies in different individuals, and it presents a striated appearance, the striæ converging towards the margin of the pupil, and being produced by the underlying vessels. The *posterior surface* is directed towards the crystalline lens and ciliary processes. It has a purple colour, and is covered by two layers of columnar epithelium, the cells of which contain dark pigment. These two layers of pigmented cells constitute the **pars iridica retinæ** (*uvea*), which is continuous with the pars ciliaris retinæ. The iris divides the space between the cornea and the crystalline lens into two compartments, the anterior chamber and posterior chamber, both of which contain the aqueous humour.

Structure.—The component parts of the iris are as follows: (1) a layer of endothelium; (2) a connective-tissue stroma, with branched cells; (3) muscular tissue; and (4) pigment.

The **layer of endothelium** covers the anterior surface of the iris, and is continuous with the endothelium which lines the posterior elastic lamina (membrane of Descemet) of the cornea.

The **connective-tissue stroma** is composed of fibres which, for the most part, pass in a radiating manner towards the pupillary margin. Some, however, are disposed circularly at the ciliary margin. They support the bloodvessels and nerves, and scattered between their bundles there are branched cells. These cells contain pigment in dark coloured eyes (black, grey, or brown), but in blue eyes they are destitute of pigment.

The muscular tissue is of the unstriped variety, and its fibres are arranged in two sets, circular and radiating. The *circular fibres* form a ring round the pupil, and are nearer the posterior surface than the anterior. They are known as the **sphincter pupillæ.** The *radiating fibres* converge from the ciliary margin of the iris towards the pupillary margin, where they blend with the circular fibres. The radiating fibres constitute the **dilator pupillæ.** Some authorities regard the radiating fibres as being elastic, and not muscular.

The **pigment** of the iris is variously situated, according to the colour of the eye. In the eyes of albinos there is no pigment.

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In other eyes pigment is contained in the cells of the two layers of columnar epithelium which line the posterior surface of the iris, and form the pars iridica retinæ (uvea). In blue eyes the pigment is confined to this region, but in dark coloured eyes (black, grey, or brown), it is also present in the branched cells of the connective-tissue stroma.

Blood-supply—Arteries.—The arteries of the iris are derived from (1) the long ciliary, and (2) the anterior ciliary, vessels.

The **long ciliary arteries** are two in number, and belong to the posterior ciliary group of branches from the ophthalmic artery. They pierce the back part of the sclerotic, one on each side of the optic nerve, and pass forwards between the sclerotic and the choroid towards the ciliary margin of the iris. Here each vessel divides into two branches, upper and lower, which anastomose with those of the opposite side to form an arterial ring round the ciliary margin of the iris, called the *circulus major*. This ring is joined by some

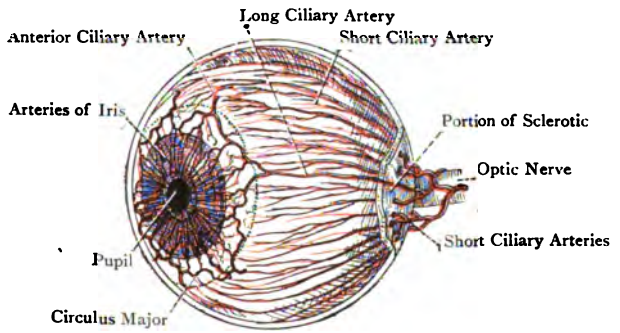

FIG. 605.—THE ARTERIES OF THE CHOROID AND IRIS (LATERAL VIEW).

of the anterior ciliary arteries, and it gives offsets to the ciliary muscle and iris. The branches which enter the iris are supported by the connective-tissue stroma, and converge towards the pupillary margin, near which they form by their anastomoses another arterial ring, called the *circulus minor*.

The **anterior ciliary arteries** are about six in number, and are derived from the muscular and lachrymal branches of the ophthalmic artery. They are of small size and pierce the anterior part of the sclerotic, close to the corneo-scleral junction. Some of them supply the ciliary processes, and others join the circulus major.

The **veins** of the iris accompany the arteries, and are in communication with the canal of Schlemm.

Nerves of the Choroid Coat and Iris.—These are derived from the ciliary nerves, short and long, the former coming from the ciliary ganglion, and the latter from the nasal branch of the

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ophthalmic or first division of the fifth cranial nerve. They are about sixteen in number, and pierce the back part of the sclerotic around the optic nerve. They then pass forwards between the sclerotic and choroid, giving branches to the latter coat, which become disposed in a plexiform manner amongst the bloodvessels. Having reached the corneo-scleral junction, the nerves enter the ciliary muscle, in which they form a plexus. From this plexus branches enter the iris at the ciliary margin. These branches accompany the vessels, and, by their subdivisions and communications, they form a copious plexus of non-medullated fibres in the connective-tissue stroma of the iris. The **sphincter pupillæ** is supplied by fibres which are derived from the oculo-motor or third

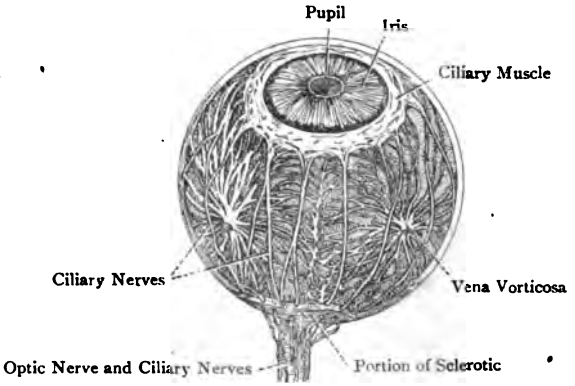

FIG. 606.—THE CHOROID AND IRIS, SHOWING THE VENÆ VORTICOSÆ AND CILIARY NERVES (AFTER HIRSCHFELD AND LEVEILLÉ).

(The Sclerotic and Cornea have been removed).

cranial nerve, through means of the motor root of the ciliary ganglion. The **dilator pupillæ** is supplied by fibres which are derived from the sympathetic through means of the sympathetic root of the ciliary ganglion.

Membrana Pupillaris.—During intra-uterine life the pupil is closed by a delicate membrane, called the **membrana pupillaris.** This membrane is vascular, except at its centre, the arteries being derived from the circulus minor, and from those of the front part of the capsule of the crystalline lens. The vessels converge from the circumference of the membrane to near its centre, and terminate by forming loops.

The membrana pupillaris disappears shortly before birth.

Internal Coat.

Retina.—The retina is the internal or nervous tunic of the eyeball. It is soft in consistence, translucent, and of a pinkish colour. Its internal surface is in contact with the hyaloid membrane,

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which encloses the vitreous body, and its external surface is in contact with the choroid coat. Posteriorly it receives the fibres of the optic nerve. Anteriorly it extends almost to the ciliary body, where it presents a notched border, called the **ora serrata.** Here its nervous elements terminate, but its pigmentary layer is continued over the deep or posterior surfaces of the ciliary processes on to the posterior surface of the iris, forming, with the addition of a layer of columnar epithelial cells, the pars ciliaris retinæ and pars iridica retinæ (uvea), respectively. The retina diminishes in thickness from behind forwards.

The *external surface* is formed by a stratum of hexagonal pigment-cells, which send processes into the adjacent layer. When the

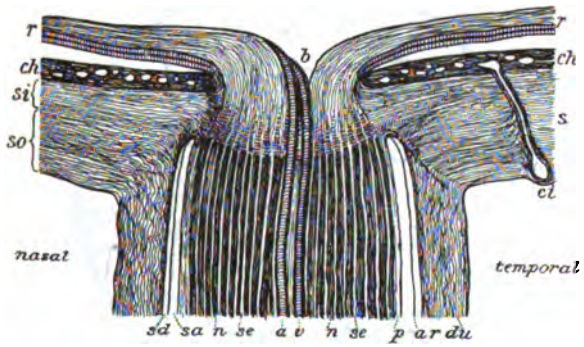

FIG. 607.—LONGITUDINAL SECTION THROUGH THE HEAD OF THE OPTIC NERVE (14 × 1) (FUCHS).

r. Retina
b. Centre of Porus Opticus
ch. Choroid
s. Sclerotic
so. Outer Part of Sclerotic
si. Inner Part of Sclerotic
ci. Ciliary Artery (in longitudinal section)

sd. Subdural Space
sa. Subarachnoid Space
n. Bundles of Nerve-fibres
se. Septa between the Nerve-bundles
a. Arteria Centralis Retinæ
v. Vena Centralis Retinæ
p. Sheath formed by Pia Mater
ar. Sheath formed by Arachnoid
du. Sheath formed by Dura Mater

nasal, Inner Side. temporal, Outer Side

choroid is separated from the retina these processes are torn, and the stratum of pigment-cells remains attached to the choroid, being apparently a part of it. The pigmentary layer, however, really belongs to the retina.

The *internal surface* presents, in the line of the visual axis of the eyeball, the **macula lutea** or **yellow spot,** where vision is most distinct. This spot is transversely oval, and measures about $\frac{1}{12}$ inch in the transverse diameter. At its centre there is a slight depression, called the **fovea centralis.** In this situation the retina is thinnest, and the dark colour of the hexagonal pigment-cells is visible through it, imparting to it the appearance of a foramen. About $\frac{1}{8}$ inch to the inner side of the posterior pole of the

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eyeball, and about $\frac{1}{12}$ inch below its level, is the **porus opticus,** or **optic disc.** This is circular in outline, and its circumference is slightly elevated. It represents the point of entrance of the fibres of the optic nerve, and the centre of the disc is pierced by the arteria centralis retinæ, which immediately divides into two branches—upper and lower. The optic disc consists entirely of nerve-fibres, and is known as the 'blind spot,' vision being absent in this situation.

Structure of the Retina.—The retina consists of eight superimposed layers, seven of which are nervous and one pigmentary.

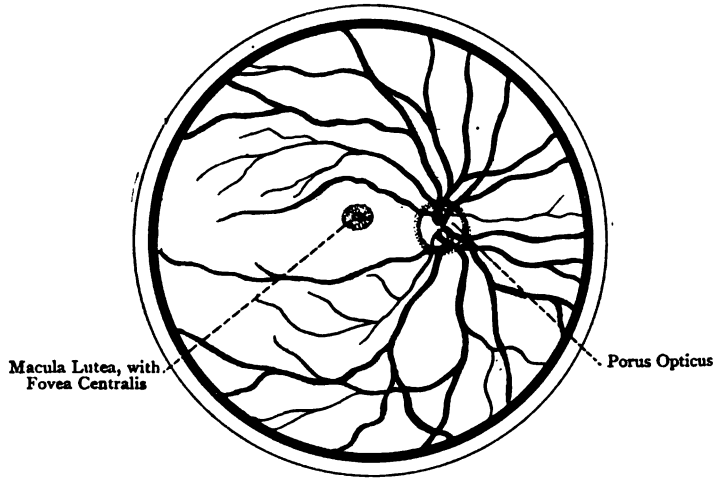

FIG. 608.—THE POSTERIOR PORTION OF THE RIGHT RETINA (ANTERIOR VIEW).

In addition to these, there are sustentacular fibres. The eight layers are as follows, from within outwards:

1. Stratum opticum, or layer of nerve-fibres.
2. Ganglionic layer, or layer of nerve-cells.
3. Inner molecular (inner plexiform) layer.
4. Inner nuclear or granular layer.
5. Outer molecular (outer plexiform) layer.
6. Outer nuclear or granular layer.
7. Layer of rods and cones, or bacillary layer.
8. Pigmentary layer.

In addition to the foregoing layers, there are two very delicate membranes, which really belong to the sustentacular fibres of the retina, but are known as the membrana limitans interna and membrana limitans externa. The **membrana limitans interna** covers the retina on its internal surface, and the **membrana limitans**

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externa intervenes between the outer nuclear layer and the bacillary layer. The layers of the retina are supported by fibres called the **sustentacular fibres.**

1. **Stratum Opticum.**—This layer consists of the fibres of the optic nerve, and it extends from the optic disc to the ora serrata. The fibres are non-medullated, and are chiefly centripetal, but some are centrifugal. The centripetal fibres arise mainly as the axons of

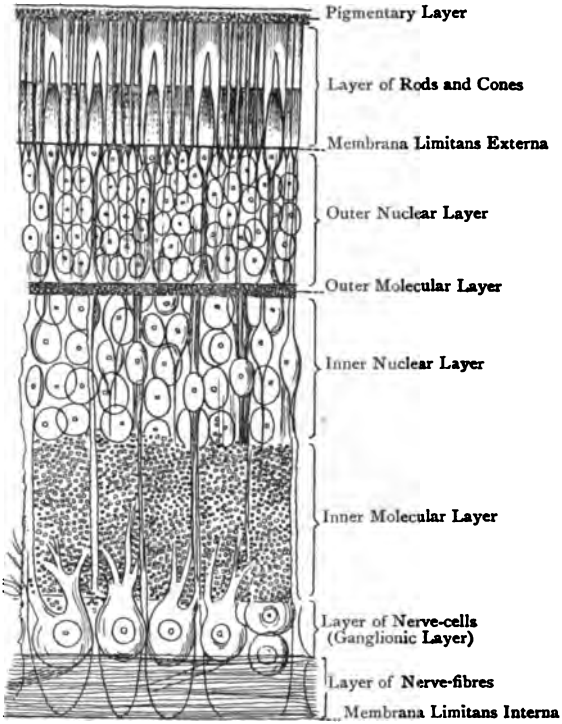

FIG. 609.—DIAGRAMMATIC SECTION OF THE HUMAN RETINA (SCHULTZE). (Copied from Quain's 'Anatomy').

the cells of the ganglionic layer. The centrifugal fibres pass towards the inner molecular and inner nuclear layers.

2. **Ganglionic Layer.**—This layer consists of large, somewhat flask-shaped, multipolar ganglion-cells, which for the most part form a single layer. In the macula lutea, however, they form several layers. The round ends of the cells rest upon the stratum opticum, and from each of these ends an axon is given off, which enters the stratum opticum obliquely, and forms one of its component fibres. The tapering end of each cell sends off several dendrites, which enter

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the inner molecular layer, within which they terminate in arborizations.

3. **Inner Molecular (Inner Plexiform) Layer.**—This layer consists of the arborizations of the dendrites of (1) the cells of the ganglionic layer, and (2) the bipolar cells of the inner nuclear layer. The intercommunications between these two sets of dendrites give rise to five strata, according to Ramon y Cajal. Besides these, there are the arborizations of the processes of the spongioblasts of the inner nuclear layer, which are likewise arranged in strata.

4. **Inner Nuclear or Granular Layer.**—This layer consists of cells which are arranged in three groups, namely, (1) bipolar cells, (2) horizontal cells, and (3) spongioblasts, or amacrine cells. The

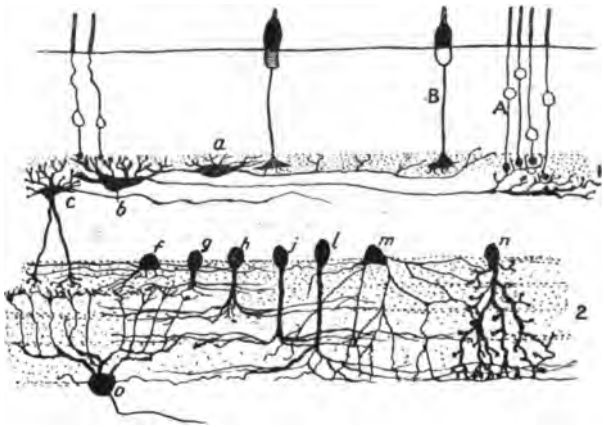

FIG. 610.—SCHEME OF THE HORIZONTAL CELLS AND SPONGIOBLASTS OF THE RETINA (RAMON Y CAJAL).

A. Rod-fibres
B. Cone-fibres
1. Outer Molecular Layer
a, *b*. Horizontal Cells, with arborizations
c. Horizontal Cell, with deep processes
2. Inner Molecular Layer
f, *g*, *h*, *j*, *l*. Spongioblasts extending to different depths
m, *n*. Spongioblasts with diffuse processes
o. Ganglionic Nerve-cell

bipolar cells are the most numerous, and are nucleated. Each cell gives off two processes—internal and external. The *internal processes* of the cells enter the inner molecular layer, and terminate at different levels in arborizations. The *external processes* pass into the outer molecular layer, and terminate in arborizations in its outermost part, which are closely related to the terminal parts of the rods and cones of the bacillary layer. According to Cajal, the bipolar cells are of two kinds—rod-bipolars and cone-bipolars. The external processes of the **rod-bipolars** ramify around the terminal parts of the rod-fibres, and the internal processes arborize around the cells of the ganglionic layer. The external processes of the **cone-bipolars** form horizontal arborizations around the terminal

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parts of the cone-fibres, and the internal processes terminate in arborizations in the inner molecular layer at different levels.

The **horizontal cells** occupy the outer part of the inner nuclear layer. Their dendrites enter the outer molecular layer, and come into relation with the terminal parts of the cone-fibres, whilst their axons run in a horizontal direction.

The **spongioblasts** are situated in the innermost part of the inner nuclear layer. They are destitute of axons, and have been called *amacrine cells*, because each cell is 'without a long fibre or process.' Their dendrites enter the inner molecular layer, and terminate in arborizations, which are arranged in strata.

5. **Outer Molecular (Outer Plexiform) Layer.**—This layer is composed of the following structures : (1) the external processes of the

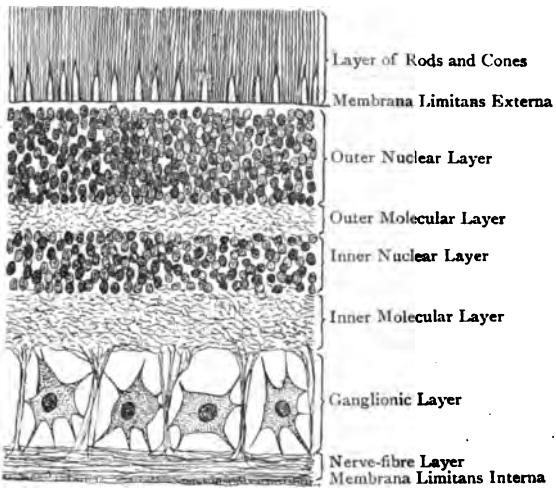

FIG. 611.—SECTION OF THE RETINA AS SEEN UNDER THE MICROSCOPE (MAGNIFIED).

rod-bipolars and cone-bipolars of the inner nuclear layer ; (2) the dendrites of the horizontal cells of the inner nuclear layer ; and (3) the terminal parts of the rod-fibres, and filaments from the foot-plates of the cone-fibres.

6. **Outer Nuclear or Granular Layer.**—This consists of granules, which are of two kinds, namely, rod-granules and cone-granules. The **rod-granules** are the more numerous, and are oval enlargements in the course of the rod-fibres, as these pass to the outer molecular layer. Each rod-fibre has only one rod-granule, and the granules lie at different levels. Each granule has a nucleus, which presents transverse striations, there being at least two clear bands. The external process of each rod-granule is continuous with one of the rods of the bacillary layer, and the internal process passes into the

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outer molecular layer, where it comes into relation with the arborizations of the external process of a rod-bipolar.

The **cone-granules** are larger than the rod-granules, but not so numerous, and each contains an oval nucleus. They are situated in the outermost part of the outer nuclear layer, close to the membrana limitans externa. The outer end of each granule is continuous with one of the cones of the bacillary layer. The inner end is prolonged into a cone-fibre, which passes into the outermost part of the outer molecular layer, where it expands into a foot-plate, from which filaments are given off. These filaments come into relation with the arborizations of the external process of a cone-bipolar cell.

7. **Layer of Rods and Cones, or Bacillary Layer.**—This layer consists of two elements, namely, rods and cones, the former being cylindrical, and the latter flask-shaped. The rods are much more numerous, longer, and narrower than the cones, and both are placed perpendicularly.

Each **rod** and **cone** consists of two segments—outer and inner. In the case of the **rods** the two segments are of almost equal length, the inner segment being rather larger than the outer. The outer segment is the only seat of the colouring matter known as *visual purple* or *rhodopsin*. In the case of the **cones,** which, as stated, are flask-shaped, the *inner* segment of each forms two-thirds of the cone, and is of large size ; whilst the *outer* segment forms one-third, is narrow, and represents the tapering part of the flask. The outer segments of both rods and cones present faint transverse striations. The inner segments of both are subdivided into two parts—outer and inner. The outer part is composed of delicate fibrils, longitudinally arranged, and therefore presents a longitudinally striated appearance. The inner part is faintly granular. The rods and cones are continued at their inner ends through the membrana limitans externa into the rod-fibres and cone-fibres, which belong to the outer nuclear layer. The outer ends of the rods project into the pigmentary layer.

8. **Pigmentary Layer.**—This is the most external layer of the retina, and it is in close contact with the choroid coat. It consists of a single layer of hexagonal epithelial cells, which contain pigment. The deep surfaces of the cells give off processes which extend into the intervals between the outer ends of the rods and cones.

Sustentacular Fibres, or Fibres of Müller.—These fibres constitute the supporting tissue of the retina, and extend from its internal surface to the boundary-line between the outer nuclear layer and the layer of rods and cones. The inner ends of the fibres are expanded, and cohere by their edges so as to present the appearance of a distinct retinal layer, which is called the **membrana limitans interna.** Their outer ends, which are very numerous owing to the breaking up of the fibres, also expand, and form what is known as the **membrana limitans externa,** which lies between the outer nuclear layer and the layer of rods and cones. (The membrana limitans

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interna and membrana limitans externa are sometimes counted as layers of the retina, under which circumstances the retinal layers would be *ten* in number, instead of eight, as stated). From the membrana limitans externa delicate offsets enter the layer of rods and cones, in the innermost part of which they form *fibre-baskets* in connection with the deep ends of the rods and cones. As the sustentacular fibres pass through the inner nuclear layer each presents an oval nucleus, which contains a nucleolus. This nucleus is variously described as being situated on one side of the fibre, or as involving its whole circumference. Throughout their course the sustentacular

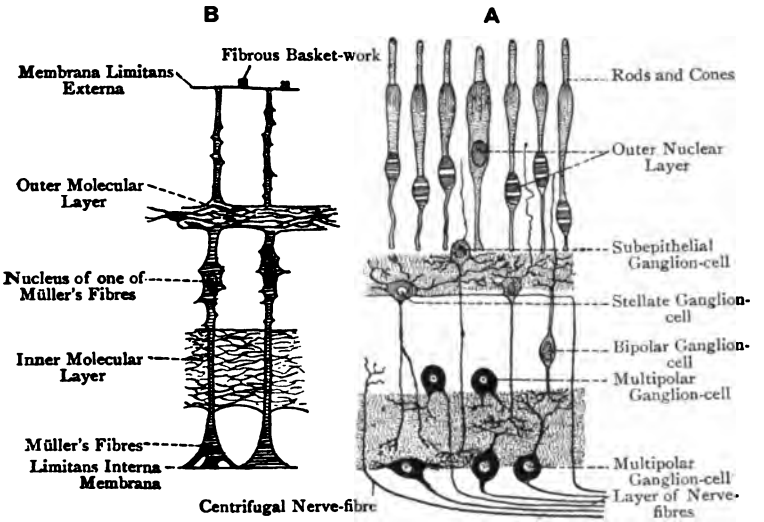

FIG. 612.—DIAGRAM OF THE ELEMENTS OF THE RETINA (WIEDERSHEIM, AFTER PH. STÖHR).

A, Nervous Elements; B, Supporting Elements.

fibres give off lateral offsets, which increase in number from within outwards.

Structure of the Macula Lutea and Fovea Centralis.—The chief structural characters of the macula lutea and fovea centralis may be stated in the following tabular manner :

Macula Lutea.	Fovea Centralis.
1. Cones only.	1. Thinnest part of the retina.
2. Outer nuclear layer has only cone-fibres, disposed obliquely.	2. Pigmentary layer thick.
3. Ganglionic layer very thick, cells being several layers deep.	3. Cones only.
4. Stratum opticum not continuously disposed.	4. Outer nuclear layer has only cone-fibres.
	5. Ganglionic layer absent.
	6. Stratum opticum absent.

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Structure of the Ora Serrata.—At the ora serrata, as previously stated, the nervous elements of the retina terminate, and its pigmentary layer is continued over the deep or posterior surfaces of the ciliary processes. In this latter situation there is superadded to its deep or posterior surface a layer of columnar epithelial cells, and the two layers form the pars ciliaris retinæ, which is continued

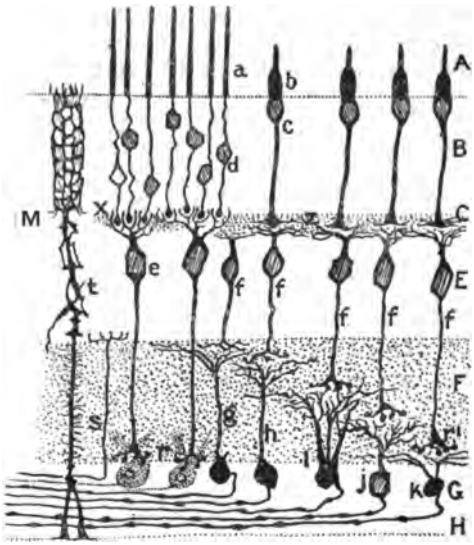

FIG. 613.—SCHEME OF THE RETINA, SHOWING THE CONNECTION BETWEEN THE LAYER OF RODS AND CONES AND THE GANGLIONIC LAYER (RAMON Y CAJAL).

A. Layer of Rods and Cones
B. Outer Nuclear Layer
C. Outer Molecular Layer
E. Inner Nuclear Layer
F. Inner Molecular Layer
G. Ganglionic Layer
H. Layer of Nerve-fibres
M. Müller's Fibre
a. Rods
b. Cones
c. Granule of Cones
d. Granule of Rods
e. Bipolar Cells of Rods
f. Bipolar Cells of Cones
g, h, i, j, k. Ganglionic Corpuscles ramifying at different levels in Inner Molecular Layer
r, r¹. Deep arborizations of Bipolar Cells
s. Centrifugal Nerve-fibre
t. Nucleus of Müller's Fibre
X. Deep ends of Rod-fibres amongst superficial arborizations of Bipolar Cells
Z. Meeting of arborizations of Cones and Bipolar Cells

into the pars iridica retinæ (uvea). In the latter the cells of both layers are pigmented.

Blood-supply of the Retina.—The retina is supplied with blood by the **arteria centralis retinæ,** which is a branch of the ophthalmic artery. Within the orbit the artery pierces the under aspect of the optic nerve a little behind the eyeball, and passes forwards in the centre of the nerve. It makes its appearance at the centre of the optic disc, and then divides into two branches, upper and lower.

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Each of these breaks up into two branches, nasal or internal, and temporal or external. The temporal branches keep clear of the macula lutea, but furnish small twigs to it, which, however, do not enter the fovea centralis, this part being non-vascular. As the branches pass inwards and outwards, respectively, towards the periphery of the retina, they ramify freely, and ultimately terminate in capillary networks. The arteries do not extend farther outwards than the inner nuclear layer. No anastomoses take place between the branches of the arteria centralis retinæ.

In the fœtus the arteria centralis retinæ furnishes a branch to the posterior part of the capsule of the crystalline lens, which reaches it through the canal of Stilling in the vitreous body.

The **veins** are ultimately collected into two vessels, upper and lower, which pass through the optic disc, one above, and the other below, the artery. They then form one vessel which opens into the superior ophthalmic vein. The veins of the retina are destitute of muscular tissue, the wall of each being formed by a single layer of endothelial cells, external to which there is a perivascular lymph-space, this, in turn, being limited by another layer of endothelial cells. These lymph-spaces are in communication with those of the optic nerve.

Relation of the retinal layers to one another.—The only two layers which are in direct continuity are the stratum opticum and ganglionic layer, some fibres of the former being the axons of the cells of the latter. As regards most of the strata, the constituent elements of successive layers are brought into communication by means of the interlacements which take place between the arborizations formed by their various processes. These interlacements occur in the inner and outer molecular layers.

In the **inner molecular layer** there are several strata of interlacements, by means of which the dendrites of the cells of the ganglionic layer are brought into communication with the internal processes of the bipolar cells of the inner nuclear layer. In the **outer molecular layer** there is a free intermingling between the external processes of the bipolar cells of the inner nuclear layer and the rod-fibres and cone-fibres.

Nerve-cells of the Retina.—These are arranged in three strata, and are in communication with one another through interlacing arborizations. The outermost stratum consists of the rods and cones; the middle stratum is formed by the bipolar cells; and the innermost stratum represents the cells of the ganglionic layer. The axons of the ganglionic cells enter the stratum opticum as centripetal fibres, which pass in the optic nerve to the brain. The centrifugal fibres of the stratum opticum ramify in the inner molecular or inner nuclear layer.

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Refracting Media.

Aqueous Humour and Chambers of the Eye.—The aqueous humour occupies the space between the cornea and the front of the crystalline lens, which is divided by the iris into two chambers, anterior and posterior. It is a clear fluid, having an alkaline reaction, and is composed of H_2O, holding in solution a very small amount of sodium chloride.

The **anterior chamber** is bounded anteriorly by the cornea, and posteriorly by the iris and the central portion of the crystalline

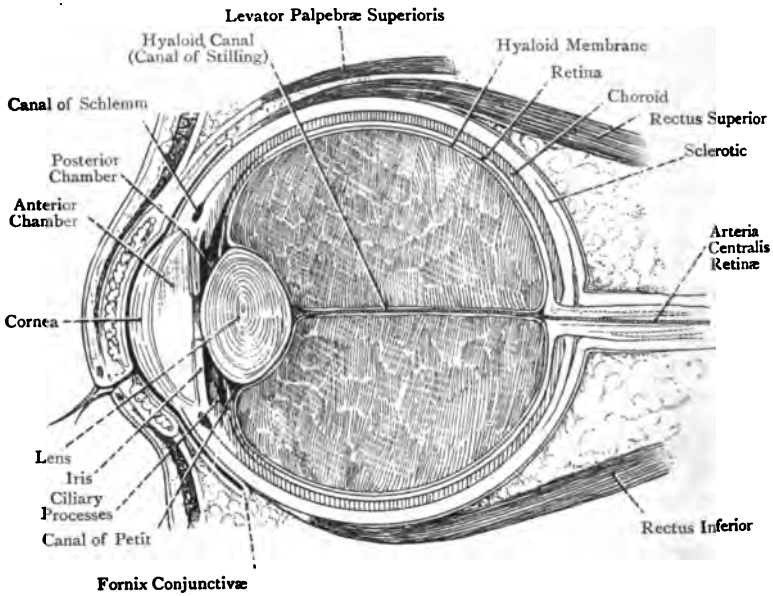

FIG. 614.—VERTICAL SAGITTAL SECTION OF THE EYE AND ITS APPENDAGES (HIRSCHFELD AND LEVEILLÉ).

lens, enclosed within its capsule. The anterior chamber communicates with the spaces of Fontana, through them with the canal of Schlemm, and through this canal with the veins of the sclerotic.

The **posterior chamber,** which is of limited extent, is bounded anteriorly by the iris, and posteriorly by the peripheral part of the crystalline lens and its suspensory ligament, and by the ciliary processes. The anterior and posterior chambers communicate with each other through the pupil; with lymph-spaces in the iris; and, through the latter spaces, with the perichoroidal lymph-space.

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Crystalline Lens.—The crystalline lens is situated directly behind the pupil and iris, from which latter it is separated by the posterior chamber. It is a solid, transparent, biconvex body, the posterior surface being more convex than the anterior, and it is enclosed within a homogeneous, transparent envelope, called the **capsule** of the lens. The centre of the anterior surface is called the **anterior pole,** and that of the posterior surface the **posterior pole.** The line connecting these two poles constitutes the **axis** of the lens, and a line surrounding the periphery represents the **equator.** The transverse measurement of the lens is about $\frac{1}{3}$ inch, and its axis measures about $\frac{1}{6}$ inch. The *anterior surface* at its central part faces the pupil. External to this, the pupillary margin of the iris rests upon it, and, external to this again, is the posterior chamber,

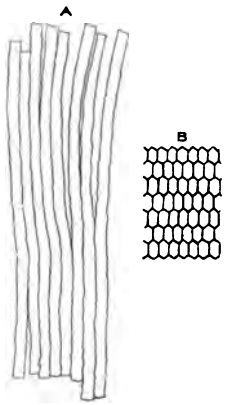

FIG. 615.—FIBRES OF THE CRYSTALLINE LENS (HIGHLY MAGNIFIED) (AFTER KOLLIKER).

A, Fibres of the Ox (seen on edge); B, Human fibres (seen on end).

with part of the aqueous humour. The *posterior surface* is received into the patellar fossa on the anterior aspect of the vitreous body. The *periphery* is related to the suspensory ligament, the canal of Petit, and the ciliary processes. From the anterior and posterior poles delicate lines radiate towards the equator. In early life these are three in number on each surface. Those on the anterior surface are directed as follows: one vertically upwards, and the other two downwards and outwards in a diverging manner, thus ⅄. Those on the posterior surface are directed as follows: one vertically downwards, and the other two upwards and outwards in a diverging manner, thus Y. These lines represent the free margins of septa within the lens, upon which the ends of the lens-fibres terminate.

Structure.—The lens is laminar in structure. The outer laminæ are soft in consistence, but the succeeding ones gradually become

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firmer, and the central portion, which constitutes **the nucleus,** is very firm and hard. The laminæ are arranged concentrically, and, after boiling or immersion in alcohol, they may be peeled off, like the coats of an onion. The fibres of which the laminæ are composed terminate upon septa within the lens, of which septa the radiating lines on the surfaces, already referred to, are the free margins. The concentric laminæ are therefore not continuous all round, but are split up along these lines. The **lens-fibres,** which are disposed in a curved manner, are of small size, and have serrated edges, which fit closely to each other. In transverse section the fibres appear as hexagonal prisms. The fibres are the elongated cells which line the posterior part of the epiblastic vesicle (lens vesicle), from which the lens is developed. In early life each fibre has a nucleus, but, after the lens has attained its full development, only the outermost fibres are nucleated.

The lens is non-vascular in the adult.

Capsule of the Lens.—This is a transparent, homogeneous, elastic, and brittle membrane, which surrounds and encloses the lens. Its anterior wall is thicker and more elastic than the posterior. In the adult it is non-vascular, but in the fœtus it receives the hyaloid branch of the arteria centralis retinæ, which reaches it through the canal of Stilling in the vitreous body.

Epithelium of the Lens.—The *posterior* surface of the lens is devoid of epithelium, and is in direct contact with the posterior wall of the capsule. The *anterior* surface is covered by a single layer of columnar cells, which intervenes between the anterior surface and the anterior wall of the capsule. Towards the equator these cells become elongated, and pass into short fibres, which become continuous with the superficial lens-fibres.

Crystalline Lens at Different Ages.—The characters of the lens at different ages are as follows :

Fœtal Lens.	Adult Lens.	Lens in Old Age.
Almost spherical.	Biconvex.	Flattened.
Pinkish colour.	Colourless.	Amber colour.
Semitransparent.	Transparent.	Opaque, more or less.
Soft in consistence.	Firm in consistence.	Very firm in consistence.

Vitreous Body.—This body occupies about four-fifths of the space within the eyeball, and is situated between the crystalline lens and the retina. It is transparent, and gelatinous in consistence, and is composed of H_2O, holding in solution a small quantity of sodium chloride and albuminous matter. It is surrounded by a transparent, homogeneous envelope, called the **hyaloid membrane.** This membrane is in contact with the retina, except anteriorly, in which latter situation it presents an excavation called the *fossa patellaris*, into which the posterior surface of the crystalline lens is received.

Towards its circumference the vitreous body is laminated, the laminæ being arranged concentrically. Laminæ are also said to

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radiate from its antero-posterior axis towards the circumference. Scattered throughout the vitreous body there are some amœboid corpuscles, and it is traversed from behind forwards by a minute passage called the **hyaloid canal,** or **canal of Stilling (canal of Cloquet**). This canal extends from the centre of the optic disc to the posterior wall of the capsule of the lens, and posteriorly it communicates with the lymph-spaces of the optic nerve. In the fœtus the canal transmits a branch of the arteria centralis retinæ, called the *hyaloid artery*, which supplies the capsule of the lens.

No vessels enter the vitreous body, its nutrition being derived from the vessels of the retina and ciliary processes.

Zonula of Zinn.—The zonula of Zinn, or **zonula ciliaris,** is the thickened portion of the hyaloid membrane which is situated in front of the ora serrata of the retina. From this point it extends inwards behind the ciliary processes towards the periphery of the crystalline lens. Behind the ciliary processes it presents radial folds with intervening depressions. The depressions receive the ciliary processes, and the radial folds are separated from the intervals between the ciliary processes by lymph-spaces, which communicate with the posterior chamber of the eye.

Suspensory Ligament of the Lens, and Canal of Petit.—The zonula of Zinn, as it approaches the periphery of the lens, divides into three layers, posterior, middle, and anterior. The *posterior layer* lines the fossa patellaris on the anterior aspect of the hyaloid membrane. The *middle layer* consists of a few scattered fibres which pass to the equator of the lens. The *anterior layer* is the thickest, and constitutes the **suspensory ligament of the lens**, which is attached to the anterior wall of the capsule of the lens not far from the equator. When the radiating fibres of the ciliary muscle contract the suspensory ligament is relaxed, and the convexity of the anterior surface of the lens is increased.

Behind the suspensory ligament of the lens there is a sacculated lymph-space, called the **canal of Petit,** which surrounds the equator of the lens.

Development of the Eye.—The various parts of the eye are developed from different sources. The optic nerve and retina are developed from the brain. The sclerotic, cornea, choroid, iris, and vitreous body are of mesoblastic origin, and the crystalline lens is of epiblastic origin.

1. The earliest stage consists in the formation of a hollow protrusion from the anterior and lateral part of the anterior primary cerebral vesicle, which protrusion is called the **primary optic vesicle.** This vesicle grows outwards towards the external epiblast and undergoes enlargement, the narrow part of it which is connected with the anterior cerebral vesicle being known as the **optic stalk.** The primary optic vesicle and the optic stalk are at first hollow, and both communicate with the anterior cerebral vesicle.

2. An invagination of the primary optic vesicle and front part of the optic stalk next takes place, this invagination being called the **optic cup,** or **secondary optic vesicle.** This leads to almost entire disappearance of the cavity of the primary optic vesicle, and the wall of the optic cup is obviously formed of two layers, outer and inner. The *outer layer* gives rise to the **pigmentary stratum** of the retina, and from the *inner layer* all the other strata of the retina, seven in number, are developed.

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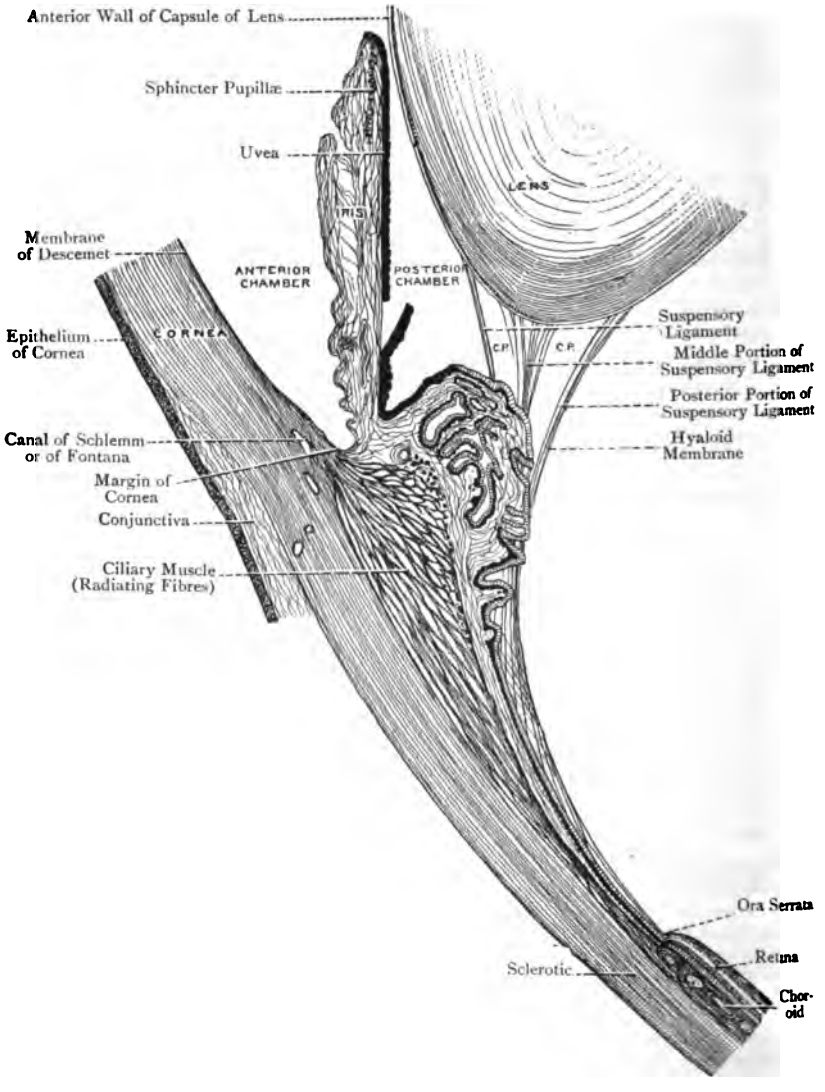

FIG. 616.—MERIDIONAL SECTION THROUGH THE ANTERIOR PORTION OF THE EYE (MAGNIFIED 16 × 1) (FUCHS).

C.P., C.P., Canal of Petit.

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3. Simultaneously with the formation of the optic cup an invagination of the epiblast takes place opposite the invagination of the primary optic vesicle which forms the optic cup. This epiblastic invagination becomes constricted at its orifice, and ultimately closed. It is then completely separated from the external epiblast, of which it was originally an invagination, and it now forms a closed sac, called the **lens vesicle,** within the optic cup. This sac is lined with epithelium, and is embedded in mesoblast which has entered the optic cup through a cleft in its lower boundary, which cleft becomes subsequently closed. The cells lining the posterior half of the epiblastic sac become elongated in a forward direction, obliterating the cavity of the sac, and coming into contact with the cells which line the anterior half. By this process of cell-elongation the fibres of the **crystalline lens** are formed. The cells lining the anterior half of the epiblastic sac do not become elongated (except at the periphery of the crystalline lens), and these cells give rise to the permanent epithelium which covers the anterior surface of the lens. The capsule of the crystalline lens may be of mesoblastic origin, or it may be developed from the cells of the lens.

The mesoblast in the optic cup, in which the lens vesicle is embedded, gives rise to the **sclerotic, cornea, choroid, iris,** and **vitreous body.**

The **optic stalks,** which latterly are connected with the thalamencephalon or diencephalon, become solid ; and form the **optic nerves.**

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THE EAR

THE organ of hearing is divided into three parts, namely, the external ear, the middle ear, and the internal ear.

External Ear.

The external ear consists of the auricle or pinna, and the meatus auditorius externus. The auricle has been already described (see p. 1114).

The **meatus auditorius externus** extends from the concha to the membrana tympani. Its direction is at first forwards and slightly upwards, then inwards, and finally forwards and downwards. Its length is rather more than 1 inch. Over about its inner two-thirds the canal is osseous, and is lodged within the petrous part of the temporal bone. The floor of the osseous part presents a slight elevation at the centre, where the passage is narrower than elsewhere, this narrow part being termed the **isthmus.** The outer third of the canal is formed by the rolled portion of the cartilage of the auricle, which is attached by fibrous tissue to the external auditory process of the temporal bone. This cartilage, as stated, presents a deficiency at the anterior and upper part, which is occupied by a fibrous membrane. It also presents a variable number of transverse clefts, called the *fissures of Santorini*, which are filled with fibrous tissue. The orifice of the meatus is oval, its long axis being vertical. Its deep extremity is nearly circular, and is closed by the membrana tympani, which is set obliquely, being inclined downwards, forwards, and towards the median line. It forms an acute angle with the lower wall, and an obtuse angle with the upper wall. In this manner the lower wall or floor is longer than the upper wall or roof, the anterior wall being also longer than the posterior wall.

The meatus is lined with skin, which is continuous with that of the auricle. In the osseous part of the canal the skin is very thin, and is provided with vascular papillæ, but is destitute of glands and hairs. It is reflected over the outer surface of the membrana tympani, of which it forms the outer layer. In the cartilaginous part of the canal the skin is thicker, and is provided with hairs, connected with the follicles of which are sebaceous glands. In

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addition to these sebaceous glands, there are convoluted tubular glands, similar in structure to sweat-glands, and called the **ceruminous glands,** which secrete the ear-wax.

Blood-supply.—The **arteries** are derived from the posterior auricular of the external carotid, the deep auricular of the first part of the internal maxillary, and the anterior auricular branches of the superficial temporal. The **veins** follow the course of the arteries.

Lymphatics.—These pass to the mastoid glands and to the parotid lymphatic glands.

Nerves.—(1) The auriculo-temporal nerve furnishes two branches to the meatus, upper and lower, which enter it by passing between

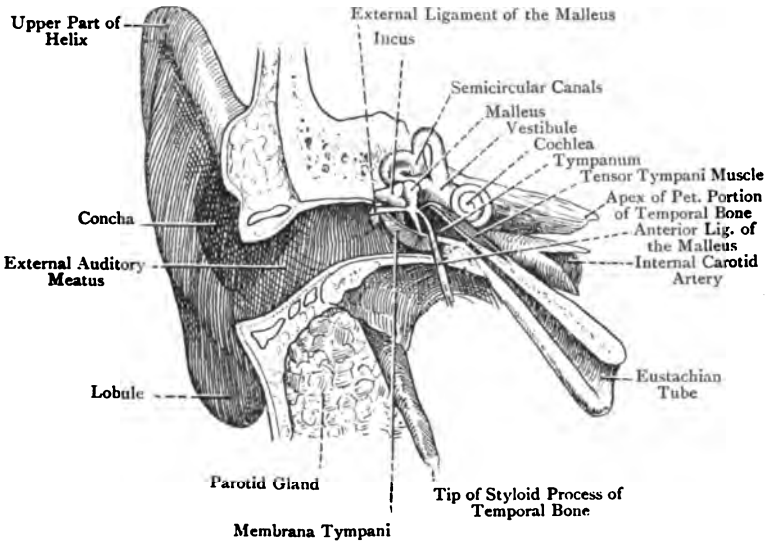

FIG. 617.—GENERAL VIEW OF THE RIGHT ORGAN OF HEARING (AFTER HIRSCHFELD AND LEVEILLÉ).

(The External Ear and Middle Ear are seen in section).

the cartilaginous and osseous walls. The upper branch furnishes twigs to the skin over the upper part of the membrana tympani. (2) The auricular branch (Arnold's nerve) of the pneumogastric supplies the skin of the osseous part of the canal over its lower and back part, and also the skin over the lower part of the membrana tympani.

Early Condition of the Meatus.—At birth the osseous part of the canal is represented merely by the *tympanic annulus* and a small portion of the squamous part of the temporal bone. It is connected by fibrous tissue to the cartilaginous framework of the auricle, and within this fibrous tissue the osseous canal becomes formed by an outgrowth from the tympanic annulus.

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Middle Ear.

The middle ear, or **tympanum,** is an irregular space within the petrous part of the temporal bone, which lies between the membrana tympani externally and the outer osseous wall of the internal ear or labyrinth internally. Its transverse measurement, opposite the centre of the membrana tympani, is about $\frac{1}{12}$ inch; from above downwards it measures about $\frac{1}{2}$ inch; and from before backwards rather more than $\frac{1}{2}$ inch. The cavity presents six walls, namely, outer, inner, roof, floor, anterior, and posterior.

The **outer wall** is formed (1) chiefly by the membrana tympani, which has the handle of the malleus fixed to it, and (2) slightly by the tympanic annulus, within the circumference of which there is a groove, called the *sulcus tympanicus*, in which the membrana tympani is set. The tympanic annulus and sulcus are interrupted superiorly by a notch, called the **notch of Rivini.** In front of the tympanic annulus is the open, inner extremity of the **fissure of Glaser,** which lodges the processus gracilis of the malleus, and transmits the tympanic branch of the internal maxillary artery. At the inner end of the fissure of Glaser is the opening of the *iter chordæ anterius*, or **canal of Huguier,** by which the chorda tympani nerve leaves the tympanum.

The **inner wall** separates the tympanum from the internal ear or labyrinth. It is very irregular, and presents the following parts:

1. The fenestra ovalis.
2. Projection formed by part of the aqueduct of Fallopius.
3. The promontory.
4. The fenestra rotunda.
5. The sinus tympani.

The **fenestra ovalis** is situated in a depression, called the **fossula ovalis,** at the upper part of the inner wall, and it leads into the cavity of the vestibule. It is irregularly oval, and is elongated from before backwards. It is occupied by the footpiece of the stapes, and the annular ligament which connects the circumference of the footpiece to the margin of the opening, the margin being covered by cartilage.

The **projection formed by part of the aqueduct of Fallopius** is situated above the fenestra ovalis. The aqueduct, which contains the facial nerve, is here directed backwards.

The **promontory** (*tuber cochleæ*) is situated below the fenestra ovalis, between it and the fenestra rotunda, and slightly anterior to both. It is a rounded prominence which is produced by the first turn of the cochlea, and it presents grooves for the nerves of the tympanic plexus.

The **fenestra rotunda** is situated in a funnel-shaped depression, called the **fossula rotunda,** below and behind the promontory. It leads into the scala tympani of the cochlea, and in the recent state is closed by the secondary membrane of the tympanum.

The **sinus tympani** is a depression situated behind the promontory, and between the fossula ovalis and fossula rotunda.

The **roof** of the tympanum is formed by a thin plate of bone,

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called the *tegmen tympani*, which forms part of the superior surface of the petrous part of the temporal bone.

The **floor** is formed by a thin plate of bone which separates the tympanum from the jugular fossa.

The **anterior wall** is narrow, owing to the descent of the roof, and the inclination towards each other of the outer and inner walls. It presents the orifices of two canals, the upper of which lodges the tensor tympani muscle, whilst the lower is the osseous part of the Eustachian tube. The two orifices are separated by the margin of the *processus cochleariformis*.

The **posterior wall** is formed by the anterior or tympanic surface

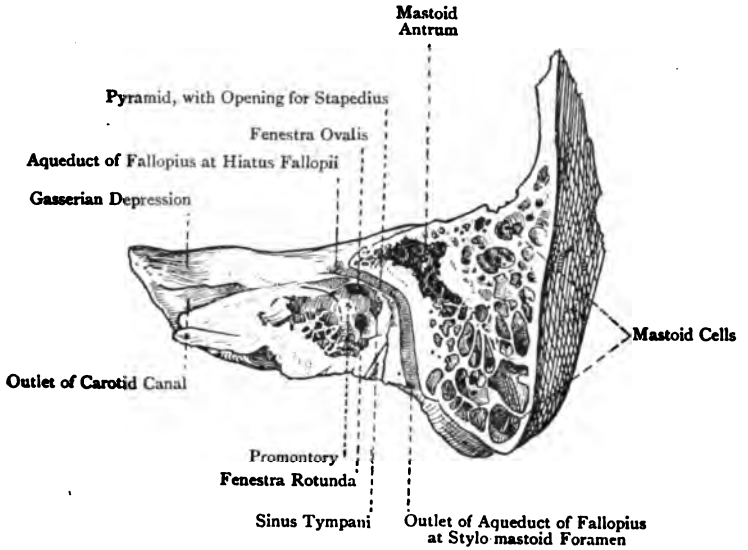

FIG. 618.—SECTION THROUGH THE PETROUS AND MASTOID PORTIONS OF THE TEMPORAL BONE, SHOWING THE TYMPANUM AND MASTOID CELLS.

of the petrous part of the temporal bone. It presents, from above downwards, the following parts: (1) the opening of the mastoid antrum, which communicates with the attic of the tympanum, or epitympanic recess; (2) a depression called the **fossa incudis,** which receives the short process of the incus; (3) a small conical projection, called the **pyramid,** the summit of which presents an opening for the passage of the tendon of the stapedius muscle; (posteriorly the canal within the pyramid, which contains the stapedius muscle, passes downwards in the posterior wall of the tympanum, and communicates with the descending part of the aqueduct of Fallopius, which contains the facial nerve, thus explaining how the branch of that nerve to the stapedius reaches the

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muscle); and (4) the **iter chordæ posterius,** for the passage of the chorda tympani nerve.

Membrana Tympani.—This is the membrane which closes the inner extremity of the meatus auditorius externus. It is situated on the outer wall of the tympanum, of which it forms the chief part, and it is set, for the most part, in the sulcus tympanicus, which marks the inner surface of the tympanic annulus. Superiorly, however, where the annulus is deficient, the membrane is attached to the notch of Rivini. This part of it is thinner and looser than the rest, and is called the **membrana flaccida,** or **Shrapnell's membrane.** The attachment of the membrana tympani to the sulcus tympanicus is effected by means of a thickened band of fibres, disposed in the form of a ring, called the *annulus fibrosus.* This annulus passes

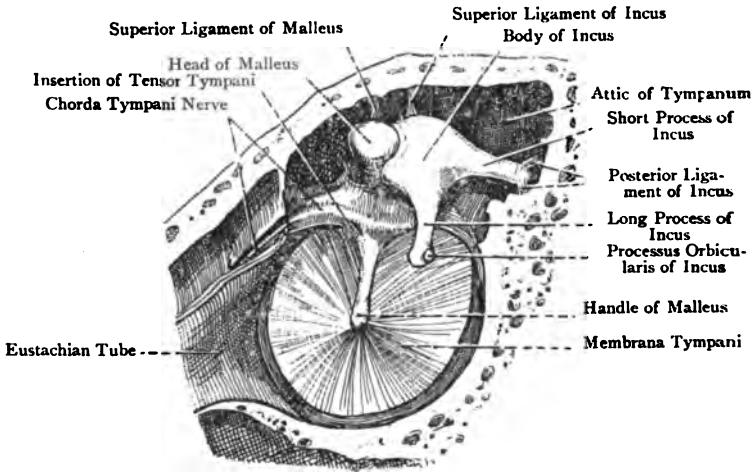

FIG. 619.—THE RIGHT MEMBRANA TYMPANI, MALLEUS, AND INCUS (INTERNAL, POSTERIOR, AND SUPERIOR VIEW) (SPALTEHOLZ).

from the extremities of the notch of Rivini to the short process of the malleus in the form of two bands, which are known as the **anterior** and **external malleolar ligaments,** and which form the lower boundary of the membrana flaccida. Opposite the notch of Rivini these annular fibres separate the membrana flaccida from the rest of the membrana tympani. The membrane is set obliquely in the sulcus tympanicus, so that its lower part forms an acute angle with the floor of the meatus auditorius externus, and its upper part an obtuse angle with the roof of the passage.

The membrana tympani is somewhat oval. In the vertical direction it measures about 10 mm., and horizontally from 8 to 9 mm. The handle of the malleus lies between the mucous and fibrous layers of the membrane, and descends to a point a little below its centre, where it ends in a small knob, from which the radi-

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ating fibres of the membrane proceed. This knob is firmly attached, and, being directed inwards, the membrane is consequently drawn inwards at that point, and its outer surface presents a slight conical depression, the deepest part of which is called the **umbo.**

Structure.—The membrana tympani consists of three layers—external, middle, and internal.

The **external** or **cutaneous layer** is very thin, and is derived from the skin of the meatus auditorius externus. It contains no glands, is freely provided with bloodvessels and nerves, and is covered by stratified squamous epithelium.

The **middle** or **fibrous layer** forms the proper substance of the membrane, and consists of fibrous tissue. The fibres are arranged in two sets—radial and circular. The *radial fibres* lie beneath the cutaneous layer, and radiate from the handle of the malleus to the annulus fibrosus. The *circular fibres* are situated within the radial fibres, and are most numerous towards the circumference of the membrane. Both sets of fibres are absent from the membrana flaccida.

The **internal** or **mucous layer** is continuous with the mucous membrane of the tympanum, and is covered by a single layer of squamous epithelium.

The **membrana flaccida,** or **Shrapnell's membrane,** is composed of two layers—cutaneous and mucous, there being no fibrous layer. These two layers are united by connective tissue, which is very loosely arranged, and this renders the membrane flaccid. This part is very liable to perforation.

Cone of Light.—Extending from the knob, in which the handle of the malleus terminates, downwards and inwards to the antero-inferior margin of the membrana tympani there is seen a specially bright reflection, triangular in outline, with the apex towards the umbo. This is called the **cone of light.**

Arterial Supply of the Membrana Tympani.—(1) Deep auricular branch of the internal maxillary artery. This vessel, which passes through the anterior wall of the meatus auditorius externus, supplies the cutaneous layer. It descends from the skin of the roof of the meatus along the course of the handle of the malleus to the umbo, where it divides into branches which radiate towards the circumference of the membrane. (2) The stylo-mastoid branch of the posterior auricular, and (3) the tympanic branch of the internal maxillary. The former artery enters the tympanum from the aqueduct of Fallopius, and the latter through the fissure of Glaser. Branches from them supply the mucous layer, and form an anastomotic ring around the circumference of the membrane. The fibrous layer receives its arterial supply from the vessels of the cutaneous and mucous layers.

The **veins** pass to the external jugular and internal jugular veins.

Nerve-supply.—The nerves are derived from (1) the auriculo-temporal of the inferior maxillary, (2) the auricular branch (Arnold's

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nerve) of the pneumogastric, and (3) branches from the tympanic plexus.

Secondary Membrane of the Tympanum.—This membrane closes the fenestra rotunda on the inner wall of the tympanum, and separates the tympanic cavity from the scala tympani of the cochlea. It is concave towards the tympanum, and, like the membrana tympani, it consists of three layers. The **external layer** is formed by the tympanic mucous membrane; the **middle layer** is fibrous; and the **internal layer** is formed by the lining membrane of the cochlea.

The mastoid antrum and mastoid air-cells will be found described in connection with the temporal bone, and a description of the Eustachian tube will be found on p. 1190.

Ossicles of the Tympanum.

The tympanum contains three small bones, arranged in the form of a chain which extends from the membrana tympani to the fenestra ovalis. The bones are the malleus, the incus, and the stapes. The malleus is related to the membrana tympani, the stapes to the fenestra ovalis, and the incus occupies an intermediate position between these two.

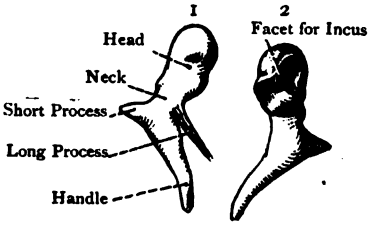

FIG. 620.—THE MALLEUS.
1, Anterior View; 2, Posterior View.

The **malleus** is so named from its resemblance to a hammer. It is composed of a head, neck, handle, and two processes, namely, long and short. The **head** is the upper, enlarged, rounded end. Posteriorly it presents a saddle-shaped facet, directed obliquely downwards and inwards, for articulation with the incus in a synovial joint. The **neck** is the constricted part below the head. The **handle** (*manubrium*) is directed downwards, inwards, and backwards from the neck; it is compressed from before backwards, and slightly curved, and it terminates in a slight knob. It lies between the fibrous and mucous layers of the membrana tympani, descending to a point a little below the centre of the membrane. It is firmly attached to the fibrous layer by its periosteum. The tensor tympani muscle is inserted into its inner part, close to its root. The **long process** (*processus gracilis*), which is slender, springs from the front of the neck, and is directed forwards and downwards to the fissure of Glaser, where it is embedded in fibres which form part of the anterior ligament of the malleus, and connect it to the margins of the fissure. The long process is in the adult for the most part replaced by fibrous tissue, except close to the neck of the malleus. In early life it is continuous with Meckel's cartilage. The **short process** (*processus brevis*) is situated immediately below the long process. It is directed outwards to the upper part of the membrana

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tympani, with which it is connected by the annulus fibrosus. It is also connected with the extremities of the notch of Rivini by those bands of the annulus fibrosus which are known as the anterior and posterior malleolar ligaments.

The **incus** has been so named from its resemblance to an anvil. It consists of a body and two processes—short and long. The **body** is thick, somewhat four-sided, and laterally compressed. Anteriorly it presents a saddle-shaped articular surface for the head of the malleus, with which it forms a synovial joint. The **short process** is directed backwards, is tipped with cartilage, and articulates with the fossa incudis on the posterior wall of the tympanum. The **long process** is directed downwards and inwards, behind and parallel to the handle of the malleus. Its lower extremity is bent inwards, and becomes narrowed into a neck, upon which is placed a disc-like knob of bone, called the **processus lenticularis seu orbicularis,** which is covered by cartilage for articulation with the head of the stapes. In early life, and up to the sixth month of intra-uterine life, this process forms a separate ossicle, called the *os orbiculare.*

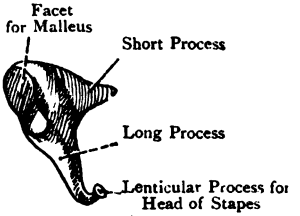

FIG. 621. — THE INCUS.
(Postero-internal View).

The **stapes** is so named from its resemblance to a stirrup. It consists of a head, neck, two crura, and a foot-piece or base. The **head** is directed outwards, is concave and covered by cartilage, and articulates with the processus lenticularis of the incus. The **neck** is the constricted part which lies immediately internal to the head. Posteriorly it gives insertion to the stapedius muscle. The **crura** are anterior and posterior respectively, and spring from the neck. They diverge as they pass inwards, and are attached to the foot-piece near its extremities. The *anterior* crus is straighter and shorter than the *posterior.* The **foot-piece** or **base** is somewhat oval, is directed inwards, and occupies the fenestra ovalis, which it almost completely fills; its circumference is covered by cartilage, being attached to the margins of the fenestra by annular ligamentous fibres. The arch formed by the crura and foot-piece is occupied by a delicate membrane, which is attached to a slight groove on the inner aspect of the arch.

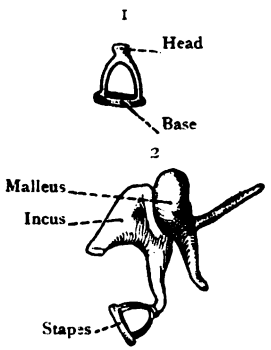

FIG. 622.—(1) THE STAPES, AND (2) TYMPANIC OSSICLES IN POSITION.

Development of the Tympanic Ossicles.—The **malleus** and **incus** are usually regarded as being developed from the proximal end of Meckel's cartilage,

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which forms the cartilaginous bar of the first or mandibular arch. According to some authorities, however, the **incus** is developed from the hyoid bar. The stapes is developed from the dorsal part of the hyoid bar of the second visceral arch, its foot-piece being derived from the labyrinth-cartilage within the fenestra ovalis.

Ligaments of the Ossicles.—The synovial joints between the malleus and incus and between the incus and stapes are provided with thin capsular ligaments. The ligaments which connect the ossicles to the walls of the tympanic cavity are five in number, three of them belonging to the malleus, one to the incus, and one to the stapes.

The **ligaments of the malleus** are anterior, posterior, and superior. The **anterior ligament** is arranged in two parts, as follows: (1) the **band of Meckel** (formerly known as the *laxator tympani muscle*), which extends from the root of the long process to the fissure of Glaser, through which it passes to be attached to the spine of the sphenoid bone; and (2) the so-called *anterior malleolar fold*, which extends from the short process to the anterior extremity of the notch of Rivini. The **posterior ligament** extends from the short process to the posterior extremity of the notch of Rivini. The **superior ligament** extends from the head of the malleus to the roof of the attic or epitympanic recess.

The **ligament of the incus** connects the short process, near its posterior extremity, to the fossa incudis.

The **annular ligament of the stapes** connects the circumference of the foot-piece, which is covered by cartilage, to the margin of the fenestra ovalis, which is also covered by cartilage.

Muscles of the Tympanum.—These are two in number, namely, the tensor tympani and the stapedius.

Tensor Tympani—*Origin.*—(1) The cartilaginous part of the Eustachian tube, superiorly; (2) the adjacent part of the great wing of the sphenoid; and (3) the wall of the osseous canal through which the muscle passes.

Insertion.—The inner aspect of the handle of the malleus, close to its root.

Nerve-supply.—A branch from the otic ganglion, and, through it, from the internal pterygoid branch of the inferior maxillary division of the fifth cranial nerve.

The muscle consists of a fleshy belly, about ½ inch long, and a delicate tendon. In passing backwards to the tympanum it lies in a canal, the entrance to which is situated within the petro-squamous angle of the temporal bone. The canal is placed above the osseous part of the Eustachian tube, from which it is separated by the *processus cochleariformis*. On entering the tympanum the tendon of the muscle bends sharply over the edge of the processus cochleariformis, and then passes outwards to reach its insertion. The tendon forms very nearly a right angle with the fleshy belly.

Action.—To render tense the membrana tympani by drawing

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inwards the handle of the malleus, and, along with it, the membrane.

Stapedius—*Origin.*—The wall of the canal within the pyramid, and of the continuation of this canal in front of the descending part of the aqueduct of Fallopius.

The tendon emerges from the canal within the pyramid through a small orifice on the apex.

Insertion.—The posterior aspect of the neck of the stapes.

Nerve-supply.—The facial nerve.

Action.—To draw the head of the stapes backwards. The result is that the front part of the foot-piece of the stapes is tilted away from the vestibule, and its back part is pressed inwards towards the vestibule.

Movements of the Ossicles.—The malleus and incus move simultaneously, the movement being one of rotation round an axis extending from the tip of the long process of the malleus to the tip of the short process of the incus. During the action of the tensor tympani muscle, when the handle of the malleus and the membrana tympani are drawn inwards, the long process of the incus is pushed inwards, and the stapes is thereby pressed inwards. The result is that the foot-piece of the stapes presses upon the perilymph of the labyrinth, and the secondary membrane of the tympanum is pressed outwards. Probably the stapedius tends to prevent undue pressure upon the perilymph of the labyrinth during strong contraction of the tensor tympani by the tilting action already ascribed to it.

Mucous Membrane of the Tympanum.—The tympanic mucous membrane is continuous anteriorly with that of the naso-pharynx through the Eustachian tube. Posteriorly it is prolonged into the mastoid antrum, and thence into the mastoid cells. It forms the internal layer of the membrana tympani, and the external layer of the secondary membrane of the tympanum. It also furnishes sheaths for the tendons of the tensor tympani and stapedius muscles, and for the chorda tympani nerve. Two folds extend downwards from the roof of the attic or epitympanic recess, one in front of, and the other behind, the superior ligament of the malleus. The former is connected with the head of the malleus, and the latter (sometimes described as the superior ligament of the incus) with the incus.

Attic or Epitympanic Recess, and its Pouches.—The part of the tympanic cavity which lies above the level of the upper margin of the membrana tympani is called the **attic** or **epitympanic recess,** as distinguished from the *atrium* or *tympanum proper.* It contains the head and neck of the malleus, and the body and short process of the incus. These divide it incompletely into two compartments—outer and inner. The **outer attic** is subdivided into two pouches—superior and inferior. The **superior pouch** is partially separated from the **inner attic** by the two mucous folds which have been already referred to as descending from the roof

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of the attic in front of and behind the superior ligament of the malleus. The **inferior pouch** of the outer attic is known as the *pouch of Prussak*. It is bounded externally by the membrana flaccida, superiorly by the external ligament of the malleus, which partially separates it from the superior pouch, and inferiorly by the short process of the malleus. The pouch communicates posteriorly with the tympanic cavity by an opening which is situated a little above the level of the bottom of the pouch. If fluid therefore should accumulate in Prussak's pouch, it may readily lead to perforation of the membrana flaccida or Shrapnell's membrane.

Two other pouches are present, namely, the **anterior** and **posterior pouches of Troltsch.** These lie one in front of, and the other behind, the handle of the malleus, and are produced by the fold of mucous membrane which invests the chorda tympani nerve.

The tympanic mucous membrane is covered, for the most part, by columnar ciliated epithelium, except over the ossicles and membrana tympani, where the epithelium consists of a single layer of squamous, non-ciliated cells.

Arteries of the Tympanum.—The principal arteries are two in number, namely, (1) the tympanic branch of the internal maxillary, and (2) the stylo-mastoid branch of the posterior auricular. The **tympanic artery** enters through the fissure of Glaser, and supplies the membrana tympani and front part of the tympanum. The **stylo-mastoid artery** enters the aqueduct of Fallopius through the stylo-mastoid foramen, and passes from the descending part of the aqueduct into the tympanum. It supplies the back part of the cavity and the mastoid cells, and it forms, with the tympanic artery, a ring round the circumference of the membrana tympani.

In addition to the foregoing two arteries, the following three arteries enter the tympanic cavity: (1) the petrosal branch of the middle meningeal, which enters from the aqueduct of Fallopius, into which it passes through the hiatus Fallopii; (2) the tympanic branch of the ascending pharyngeal, which accompanies Jacobson's nerve through the tympanic canaliculus; and (3) the tympanic branch of the internal carotid, which enters by a minute foramen on the posterior wall of the ascending part of the carotid canal, in company with a sympathetic twig from the carotid plexus.

The **veins** of the tympanum pass to the pterygoid plexus, the superior petrosal sinus, the internal jugular vein, and the pharyngeal plexus.

Nerves of the Tympanum—1. **Tympanic Plexus.**—This plexus is situated on the inner wall of the tympanic cavity, more particularly over the promontory. It is formed by (*a*) the tympanic branch (Jacobson's nerve) of the petrous ganglion of the glosso-pharyngeal, and (*b*) the carotico-tympanic branch of the carotid plexus of the sympathetic.

Branches.—These are distributed to the mucous membrane of the tympanum, Eustachian tube, and mastoid cells. Besides these, there are two named branches, called the small superficial petrosal and the small deep petrosal. The **small superficial petrosal nerve** is to be regarded as the continuation of Jacobson's nerve. After issuing from the tympanic plexus it leaves the tympanum at the upper part of the anterior wall, and traverses a small canal in the petrous part of the temporal bone, passing beneath the upper portion of the canal which lodges the tensor tympani muscle. Whilst in this canal it is joined by a small branch from the geniculate ganglion of the facial nerve, and it emerges from the canal through the accessory hiatus on the superior surface of the pars petrosa. It then passes forwards and inwards beneath the dura mater, and leaves the cranial cavity through the canaliculus innominatus, or through the fissure between the pars petrosa and the great wing of the sphenoid, or through the foramen ovale. Having entered

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the zygomatic fossa, it joins the otic ganglion, to which it conducts glossopharyngeal fibres.

The **small deep petrosal nerve** passes forwards through a minute canal within the processus cochleariformis to the upper aspect of the foramen lacerum medium, where it joins the carotid plexus of the sympathetic and the great deep petrosal, or, it may be, the great superficial petrosal, nerve. In this manner some of its fibres pass in the Vidian nerve to Meckel's ganglion.

2. **Chorda Tympani Nerve.**—This nerve arises from the facial nerve in the lower portion of the descending part of the aqueduct of Fallopius. Having ascended for a little in the aqueduct, it leaves it by passing forwards through a minute canal, called the *iter chordæ posterius*, which opens on the posterior wall of the tympanum, below the level of the pyramid. The nerve, invested by a fold of mucous membrane, now passes forwards internal to the membrana tympani, and over the upper part of the handle of the malleus. It then leaves the tympanic cavity through a passage situated at the inner end of the fissure of Glaser, called the *iter chordæ anterius*, or **canal of Huguier,** after which it joins the lingual nerve.

Internal Ear.

The internal ear is the essential part of the organ of hearing, and is known as the **labyrinth** from its remarkable complexity. It consists of two parts, namely, the osseous labyrinth and the membranous labyrinth.

Osseous Labyrinth.

The osseous labyrinth is a cavity situated within the petrous part of the temporal bone, and it is divided into three parts, namely, the **vestibule**, the **semicircular canals**, and the **cochlea.** These divisions are lined with a delicate periosteum, between which and the contained membranous labyrinth there is a clear fluid, called the **perilymph.**

Vestibule.—The vestibule is the central division of the osseous labyrinth. The semicircular canals lie behind it, and the cochlea is situated in front of it. The *outer wall* presents the fenestra ovalis, which is occupied by the foot-piece of the stapes and its annular ligament. The *inner wall* presents anteriorly a depression called the **fovea spherica**, which corresponds to the lamina cribrosa at the deep end of the meatus auditorius internus. It is pierced by apertures for the passage of filaments of the auditory nerve to the saccule. Behind and above the fovea spherica there is a ridge, called the **crista vestibuli,** which lies obliquely. Posteriorly it bifurcates, and between its two divisions there is a small depression, called the **recessus cochlearis,** which presents a few openings for the passage of nerve filaments to the canalis cochleæ. Anteriorly it becomes somewhat triangular, and forms the **pyramid**, which is pierced by foramina for the passage of nerves to the utricle.

The roof of the vestibule, behind and above the crista vestibuli, presents an oval depression, called the **fovea elliptica,** which encroaches on the inner wall and lodges the **recessus utriculi.** It is pierced by foramina for the passage of the nerves to the ampullæ

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of the superior and external semicircular canals. Below the fovea elliptica is the opening of the aqueductus vestibuli, which leads to the posterior surface of the petrous part of the temporal bone, about ¼ inch external to the orifice of the meatus auditorius internus. It transmits the ductus endolymphaticus and a minute vein.

Anteriorly the vestibule communicates with the scala vestibuli

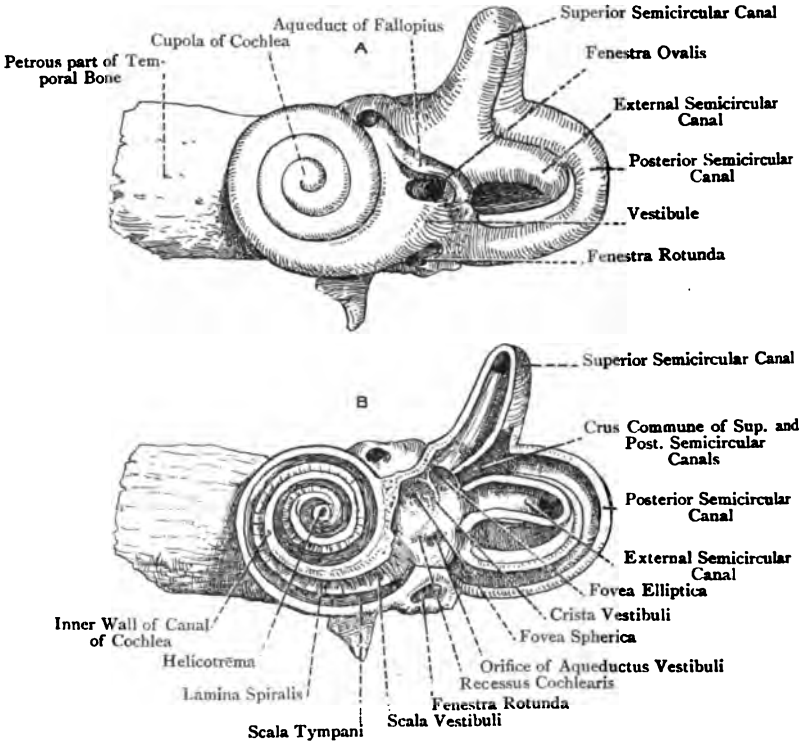

FIG. 623.—THE OSSEOUS LABYRINTH OF THE LEFT SIDE (EXTERNAL VIEW).

A, Entire; B, Opened (Hirschfeld and Leveillé. B, Modified).

of the cochlea, and posteriorly it presents the five openings of the semicircular canals.

Semicircular Canals.—The **osseous semicircular canals** are situated behind the vestibule. They are three in number—superior, posterior, and external—and they open into the vestibule by five circular apertures, the contiguous ends of the superior and posterior canals having a common orifice. Each canal forms about two-thirds of a circle, and each presents at one end an enlargement,

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called the **ampulla**. The **superior semicircular canal** occupies a vertical position, and lies transversely as regards the long axis of the petrous part of the temporal bone, giving rise to the *eminentia arcuata* on its superior surface. Its ampullary end (antero-external) opens independently into the upper part of the vestibule, above the ampullary orifice of the external canal. Its non-ampullary end unites with the non-ampullary end of the posterior canal, and the two open by a common orifice into the vestibule. The **posterior semicircular canal** arches backwards towards the posterior surface of the pars petrosa, with which it is almost parallel, and, like the superior, it occupies a vertical position. Its ampullary end (inferior) opens independently into the lower and back part of the vestibule, and its non-ampullary end, as just stated, joins that of the superior canal. The **external semicircular canal** arches outwards, and occupies a horizontal position. Its extremities are independent of those of the other two canals, and they open by separate apertures into the upper and back part of the vestibule. Its ampullary end is external.

Cochlea.—The osseous cochlea is situated in front of the vestibule. It consists of a tube coiled spirally upon itself, like a snail's shell, and is of conical outline. Its base is opposite the lamina cribrosa at the deep end of the meatus auditorius internus; and its apex, known as the **cupola,** is directed outwards and slightly forwards towards the canal which contains the tensor tympani muscle. Its length from base to apex is about $\frac{1}{5}$ inch. It consists of the following parts: (1) a central pillar, called the **modiolus**; (2) a canal, winding spirally round the modiolus; and (3) an osseous plate, called the **lamina spiralis,** which projects from the modiolus into the canal throughout its windings.

The **modiolus** is the central pillar of the cochlea. It commences at the cochlear area of the lamina cribrosa, and extends almost to the apex or cupola. It contains canals, which transmit branches of the cochlear division of the auditory nerve and of the internal auditory artery to the lamina spiralis. At the attached margin of the lamina spiralis these canals become united and form the **spiral canal** of the modiolus, which lodges the spiral ganglion, or ganglion of Corti, and communicates freely with the lamina spiralis.

The *lamina cribrosa*, at the deep end of the meatus auditorius internus, will be found described on p. 73.

The **canal of the cochlea** winds spirally round the modiolus, which forms its inner wall, and it describes two and three-quarter turns. At the cupola it terminates in a blind extremity. Its length is about 30 mm. and its breadth at the base about 2 mm. The first turn of the canal gives rise to the promontory on the inner wall of the tympanum.

The **lamina spiralis** is a shelf of bone which projects from the modiolus into the canal of the cochlea throughout its windings, and it divides the canal incompletely into two passages—an upper or scala vestibuli, and a lower or scala tympani. The lamina

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spiralis extends across the canal towards its outer wall for about half its width, and in the recent state the remainder of the distance is completed by the basilar membrane. Close to the cupola the lamina spiralis ends in a hook-like process, called the *hamulus*. The spiral lamina consists of two plates of bone, between which there are canals for branches of the cochlear division of the auditory nerve and of the internal auditory artery. These canals open out from the spiral canal of the modiolus.

At the lower end of the scala tympani is the upper opening of the **aqueductus cochleæ,** which passes downwards and inwards to terminate on the posterior border of the petrous part of the temporal bone. It transmits a small vein to the inferior petrosal sinus, and

FIG. 624.—MEDIAN SECTION OF THE LEFT OSSEOUS COCHLEA OF MAN FROM APEX TO BASE (ARNOLD).

S.V. Scala Vestibuli
S.T. Scala Tympani
L.S.O. Lamina Spiralis Ossea
C.C. Central Canal of Modiolus
M.A.I. Meatus Auditorius Internus

establishes a communication between the scala tympani and the subarachnoid space.

Membranous Labyrinth.

The membranous labyrinth is situated within the osseous labyrinth, and its constituent parts receive the terminal branches of the auditory nerve. It is separated from the periosteal lining of the osseous labyrinth by the **perilymph,** and it contains the fluid known as the **endolymph.** In the case of the vestibule and the osseous semicircular canals the membranous labyrinth corresponds, more or less, with them ; but in the case of the osseous cochlea it forms part of the septum between the scala tympani and scala vestibuli, and contains a passage called the membranous canal of the cochlea.

Vestibular Part of the Membranous Labyrinth.—The vestibule

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contains two membranous sacs, namely, the utricle and the saccule, which are in close contact, but do not communicate with each other directly.

The **utricle** is the larger of the two sacs, and into it the membranous semicircular canals open. It occupies the upper and back part of the vestibule, a portion of it, known as the **recessus utriculi,** lying in the fovea elliptica. In the vicinity of the crista vestibuli the wall of this recess receives fibres of the auditory nerve and is thickened, this portion of it being called the **macula acustica utriculi.** From the anterior and inner part of the utricle a minute canal, called the **ductus utriculi** (*ductus utriculo-sacculares*), passes to join the ductus sacculi, and so form the ductus endolymphaticus.

The **saccule,** which is somewhat oval, lies in front of the utricle, and occupies the fovea spherica, where it is contiguous to the opening leading into the scala vestibuli of the cochlea. Through the openings of the fovea spherica it receives filaments of the auditory nerve, and this portion of the saccule being thickened, is known as the *macula acustica sacculi.* Inferiorly the saccule is connected with a small canal, called the **canalis** or **ductus reuniens of Hensen,** which opens into the canal of the cochlea, or ductus cochlearis, not far from its closed vestibular end. From the posterior part of the saccule a minute canal, called the **ductus sacculi,** passes off, which is soon joined by the **ductus utriculi,** and so the **ductus endolymphaticus** is formed. This latter duct traverses the aqueductus vestibuli, and, having reached the posterior surface of the petrous part of the temporal bone, it ends in a small blind dilatation, called the *sacculus endolymphaticus,* which lies beneath the dura mater. The saccule and utricle are thus indirectly connected by means of the ductus sacculus and ductus utriculus; and the saccule communicates with the ductus cochlearis by means of the canalis or ductus reuniens of Hensen.

Semicircular Canals.—The membranous semicircular canals correspond in outline to the osseous semicircular canals, within which they lie; they form about two-thirds of a circle; and each presents an **ampulla** at one extremity, which is situated within the ampulla of the osseous canal. They are elliptical in transverse section, and open into the utricle by five orifices, the non-ampullary ends of the superior and posterior canals being united, so that these two ends open by a common orifice. The *convex* wall of each canal is attached to the periosteal lining of the osseous canal, whilst the *concave* wall is practically free from the osseous wall, and is bathed by the perilymph.

Structure.—The walls of the utricle, saccule, and membranous semicircular canals consist of three layers, namely, (1) an outer or fibrous layer, which is vascular; (2) a middle layer, or membrana propria, which is translucent; and (3) an inner or epithelial layer. In each ampulla the middle layer, or **membrana propria,** projects into the cavity of the canal from the peripheral wall, this projecting

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part being known as the *septum transversum.* It partially divides the interior of the ampulla into two compartments, and its free margin, which is covered by the auditory epithelium, is called the **crista acustica.** The **epithelial layer** consists of a single stratum of squamous cells, except in those regions to which the filaments of the auditory nerve are distributed. These regions are as follows: (1) the macula acustica utriculi; (2) the macula acustica sacculi; and (3) the crista acustica of each ampulla.

The **macula acustica utriculi** is the thickened part of the antero-inferior wall of the recessus utriculi, and is lined with auditory epithelium. The macula is covered by calcareous particles, called *otoliths* or *otoconia*, which consist of crystals of calcium carbonate. The **macula acustica sacculi** is the thickened part of the anterior wall of the saccule, and is also lined with auditory epithelium,

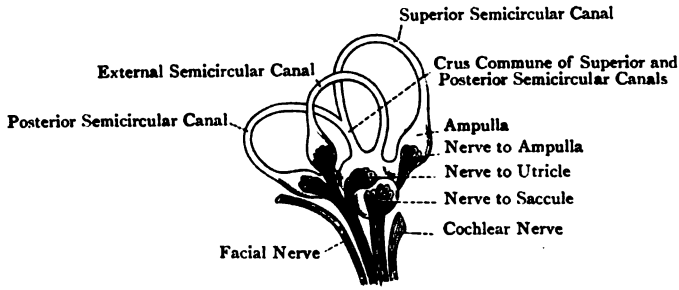

FIG. 625.—THE MEMBRANOUS SEMICIRCULAR CANALS, SHOWING THE DISTRIBUTION OF THE BRANCHES OF THE AUDITORY NERVE TO THEIR AMPULLÆ (BRESCHET).

covered by otoliths. The **crista acustica,** as stated, is the free margin of the septum transversum in each ampulla, and is covered by auditory epithelium.

The **auditory epithelium** is of the columnar variety, and consists of two kinds of cells, auditory and sustentacular. The **auditory cells** are nucleated, and each is provided at its free extremity with slender, tapering, hair-like filament, which projects into the cavity. These filaments are sometimes spoken of collectively as *auditory hairs*, and the cells are hence called **hair-cells.** Their deep extremities fall short of the membrana propria. The **sustentacular cells** lie between the hair-cells, and are elongated and nucleated. Their deep extremities are attached to the membrana propria, and their free extremities give rise to a kind of limiting membrane. The auditory nerve-fibres pierce the membrana propria, and, having lost their medullary sheaths, the axons terminate in arborizations around the deep ends of the auditory or hair cells.

Membranous Cochlea.—The membranous cochlea is situated within the osseous cochlea, and completes the deficiency which is left by the lamina spiralis. It consists of two membranes, namely,

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the basilar membrane and the membrane of Reissner, which enclose between them the ductus cochlearis, or scala media. The cochlear tube in the recent state is therefore divided into three spiral passages, namely, (1) the scala tympani, (2) the scala vestibuli, and (3) the scala media. The scala vestibuli is continuous with the scala tympani at the cupola through means of an aperture, called the *helicotrēma*; and at the base of the cochlea it opens upon the anterior wall of the vestibule. The scala tympani commences at the fenestra rotunda, and in the recent state is separated from the tympanic cavity by the secondary membrane of the tympanum. The scala media, or ductus cochlearis, communicates, near its lower end, with the saccule by means of the canalis or ductus reuniens of Hensen. The scala vestibuli and scala tympani contain perilymph, which is continuous with the perilymph of the vestibule and osseous semicircular canals. The scala media contains endolymph, which is continuous with that of the saccule.

Basilar Membrane.—The basilar membrane extends from the free margin of the lamina spiralis to the *crista basilaris*, or lower

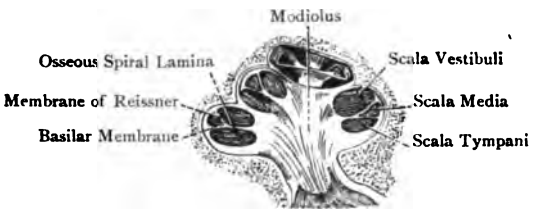

FIG. 626.—VERTICAL SECTION OF THE COCHLEA OF A FŒTAL CALF, SHOWING THE SCALÆ AND MODIOLUS (KOLLIKER).

part of the **spiral ligament,** which ligament is a thickening of the periosteum of that part of the outer wall of the cochlea which forms the outer wall of the scala media, or ductus cochlearis. It separates the scala media from the scala tympani, and is divisible into two zones, inner and outer. The inner zone is called the *zona arcuata*, and it supports the organ of Corti. The outer zone is called the *zona pectinata*, and it extends from the foot-plates of the outer rods of Corti to the crista basilaris. The basilar membrane consists of a homogeneous membrana propria, with fibres embedded in it, the fibres being most numerous in the zona pectinata.

Membrane of Reissner.—This is a delicate membrane which extends from the upper surface of the lamina spiralis, a short distance from its free margin, to the outer wall of the cochlea, where it is attached to the periosteum at a point a short distance above the outer attachment of the basilar membrane. It separates the scala media from the scala vestibuli, and consists of a very delicate connective-tissue membrane, lined on each side with a single layer of squamous epithelium.

The scala media, or **ductus cochlearis,** is situated between the

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basilar membrane and the membrane of Reissner. It is triangular in transverse section, and presents a roof, an outer wall, and a floor. The **roof** is formed by the membrane of Reissner, which, as just stated, separates the scala media from the scala vestibuli. The **outer wall** is formed by the outer wall of the cochlea and its periosteum, between the external attachments of the basilar membrane and the membrane of Reissner. The periosteum in this region is much thickened, and forms the **spiral ligament of the cochlea,** the lower part of which gives rise to the crista basilaris. The **floor** is formed by (1) the basilar membrane, and (2) the portion of the upper surface of the lamina spiralis which lies external to the attachment of the membrane of Reissner. As stated, the basilar membrane separates the scala media from the scala tympani. The scala media terminates above in a closed extremity at the cupola, and it has a similar mode of termination at the base of the cochlea. Near its lower blind extremity it receives the canalis or ductus reuniens of Hensen, by which it communicates with the saccule.

As just stated, part of the floor of the scala media is formed by that portion of the upper surface of the lamina spiralis which lies external to the attachment of the membrane of Reissner. In the recent state it is of some thickness, which is due to a thickening of its periosteal covering. This fibrous thickening forms the **limbus laminæ spiralis.** Its outer margin is crescentic, the deep notch being called the *sulcus laminæ spiralis.* The sulcus has two lips, upper and lower. The upper lip is called the *labium vestibulare,* the upper surface of which is marked by several interlacing prominences and grooves. At the free margin of this labium the prominences assume the form of tooth-like projections, which are known as the **auditory teeth.** The lower lip of the sulcus is called the *labium tympanicum.* It is continued into the basilar membrane, and is perforated by a great number of apertures for the branches of the cochlear division of the auditory nerve.

Organ of Corti.—Over the upper surface of the inner part (zona arcuata) of the basilar membrane the epithelium undergoes remarkable modification, and gives rise to the **organ of Corti.** The constituent parts of this very complicated organ are as follows :

1. The rods of Corti.
2. The auditory or hair-cells.
3. The cells of Deiters.
4. The cells of Hensen and of Claudius.
5. The lamina reticularis.
6. The membrana tectoria.

The **rods of Corti** are arranged in two rows, inner and outer. The rods of the inner row are spoken of as the **inner rods,** and those of the outer row as the **outer rods.** Each rod consists of a foot-plate or base, an intermediate portion, and a head, which latter represents the upper extremity. The **foot-plate,** which is expanded, rests upon the zona arcuata of the basilar membrane, and the foot-plates of the inner rods are separated from those of the outer rods by a slight

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interval. As the rods rise the **intermediate portions** of the inner and outer rods incline towards each other, and the **heads** of the two sets of rods come into contact. In this manner a triangular tunnel is enclosed between the two sets of rods and the basilar membrane, which is called the **tunnel of Corti**. This tunnel extends along the entire length of the scala media, or ductus cochlearis.

The inner and outer rods present certain differences.

The **inner rods** are more numerous than the outer, there being from 5,000 to 6,000 of the former, and about 4,000 of the latter. They incline upwards and outwards. The **head** of each is

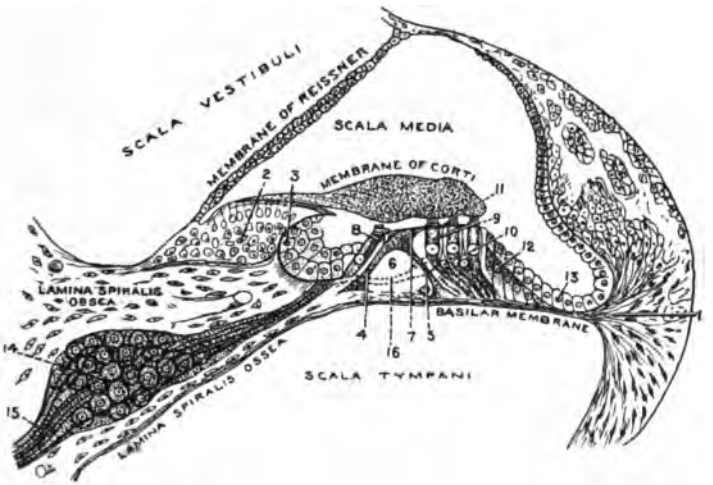

FIG. 627.—THE ORGAN OF CORTI (WIEDERSHEIM, AFTER LAVDOWSKY).

1. Spiral Ligament
2. Limbus
3. Sulcus Spiralis
4. Inner Rod of Corti
5. Outer Rod of Corti
6. Tunnel of Corti
7. Phalangeal Process of Outer Rod
8. Inner Hair-cells
9. Outer Hair-cells
10. Cells of Deiters
11. Lamina Reticularis
12. Cells of Hensen
13. Cells of Claudius
14. Spiral Ganglion
15. Cochlear Nerve
16. Nerve-fibres to Hair-cells

directed outwards and presents a concavity, above and below which there is a projecting portion, so that it resembles, somewhat, the upper extremity of the ulna, with its great sigmoid cavity and olecranon and coronoid processes. The concavity on the head of the inner rod receives the round portion of the head of the outer rod. Finally, the inner rods are shorter than the outer rods. The **outer rods** are less numerous and longer than the inner, and they incline upwards and inwards. The **head** of each is divisible into two parts—inner and outer. The ***inner part*** is round, and is received into the concavity on the outer aspect of the head of the inner rod. The ***outer part*** is prolonged into a beak-like pro-

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jection, called the **phalangeal process,** which forms part of the lamina reticularis, to be presently described.

The **auditory** or **hair-cells** are arranged in two sets—inner and outer. The **inner hair-cells** are situated internal to the row of inner rods, and are disposed in a single row. They are from 3,000 to 4,000 in number. Their free extremities, which lie close to the heads of the inner rods, are each provided with a tuft of short, hair-like filaments. The deep, nucleated ends of the cells are related to the terminal arborizations of nerve-fibres. Internal to the row of inner air-cells there are two or more rows of columnar cells, which are continuous with the columnar epithelium of the sulcus spiralis laminæ. The **outer hair-cells** are disposed in three or four rows external to the outer row of rods. They are much more numerous than the inner hair-cells. Their free extremities, like those of the inner cells, are each provided with a tuft of short, hair-like filaments, and their deep, nucleated ends are related to the terminal arborizations of nerve-fibres.

The **cells of Deiters,** which are sustentacular, are situated between the rows of outer hair-cells. They rest by an expanded base upon the

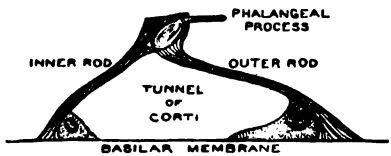

FIG. 628.—A PAIR OF RODS OF CORTI, FROM THE RABBIT'S COCHLEA, SIDE VIEW (HIGHLY MAGNIFIED) (SCHÄFER IN QUAIN'S 'ANATOMY').

basilar membrane, where they support the outer hair-cells; and their narrow, tapering upper extremities extend to the lamina reticularis, where they expand slightly, and form phalangeal processes of that lamina. Each cell is nucleated.

The **cells of Hensen** are disposed as a continuous layer, external to, and in continuation of, the lamina reticularis.

External to the cells of Hensen there are the columnar **cells of Claudius.**

The **lamina reticularis** is a delicate layer which extends between the heads of the outer rods of Corti and the cells of Hensen. It is composed of **phalangeal processes,** which are derived from (1) the heads of the outer rods of Corti, and (2) the upper extremities of the cells of Deiters. Between the processes there are apertures, through which the outer extremities of the outer hair-cells, with their tufts of hair-like filaments, project. The phalangeal processes are arranged in rows, those of the innermost row being formed by the phalangeal processes of the heads of the outer rods of Corti.

The **membrana tectoria,** or **membrane of Corti,** is an elastic membrane which extends from the upper surface of the lamina spiralis,

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near and external to the lower attachment of the membrane of Reissner, to the outer hair-cells. It covers the limbus laminæ spiralis, the labium vestibulare, the inner hair-cells, and the inner and outer rods of Corti.

Auditory Nerve.—The auditory nerve, within the meatus auditorius internus, breaks up into two divisions—vestibular and cochlear.

The **vestibular nerve,** as it traverses the meatus auditorius internus, presents a gangliform enlargement, called the **ganglion of Scarpa,** and it divides into three branches. These enter the vestibule through the foramina in the superior vestibular area of the lamina cribrosa at the deep end of the internal meatus. They are distributed to the macula acustica utriculi and to the cristæ acusticæ of the ampullæ of the superior and external semicircular canals.

The **cochlear nerve,** in the meatus auditorius internus, furnishes two branches—one to the macula acustica sacculi, and the other to

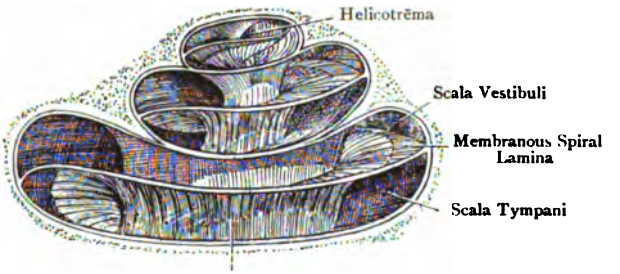

FIG. 629.—SECTION OF THE COCHLEA, SHOWING THE DISTRIBUTION OF THE COCHLEAR BRANCH OF THE AUDITORY NERVE (MAGNIFIED) (HIRSCHFELD AND LEVEILLÉ).

the crista acustica of the ampulla of the posterior semicircular canal. The filaments of the former, which has a gangliform enlargement, pass through the foramina in the inferior vestibular area of the lamina cribrosa, and the latter passes through the foramen singulare in the lamina cribrosa. The cochlear nerve, having parted with these two branches, breaks up into filaments which pass through the foramina of the cochlear area of the lamina cribrosa, and so reach the base of the modiolus of the cochlea. They traverse the canals of the modiolus, from which they pass into the canals between the two layers of the lamina spiralis. In doing so they have to cross the **spiral canal** of the modiolus, which is situated close to the attached margin of the lamina spiralis. This canal contains a ganglion, called the **spiral ganglion,** which pursues the windings of the canal, and consists of bipolar nerve-cells. As the auditory fibres pass from the canals of the modiolus into the canals of the lamina spiralis, the course of each fibre is probably

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interrupted by a bipolar cell of the spiral ganglion in the spiral canal. The nerve-fibres, having emerged from these bipolar cells, traverse the canals between the two layers of the lamina spiralis. Having lost their medullary sheaths, they emerge through the foramina of the labium tympanicum on the outer margin of the limbus laminæ spiralis, and enter the basilary membrane, where they terminate in arborizations which are connected with the inner and outer hair-cells.

Blood-supply of the Labyrinth.—The labyrinth derives its blood from the **internal auditory artery,** which is a branch of the basilar artery. The vessel traverses the meatus auditorius internus, and divides at its deep end into two branches—vestibular and cochlear. The **vestibular artery** supplies the utricle, saccule, and semicircular canals, and the **cochlear artery** supplies the cochlea.

The **veins** of the labyrinth ultimately join, for the most part, to form one vessel, called the **internal auditory vein,** which opens into the inferior petrosal sinus. The aqueductus cochleæ and the aqueductus vestibuli each transmit a vein, that which passes through the former terminating in the inferior petrosal sinus or in the bulb of the internal jugular vein, and that which passes through the latter terminating in the superior petrosal sinus.

Development of the Ear.—The **membranous labyrinth** is developed from the **auditory pit,** which is an invagination of the external epiblast, on either side, over the upper end of the first visceral cleft, in the region of the hind-brain. This pit becomes closed by the fusion of its margins, and thus gives rise to the **otic** or **auditory vesicle.** This vesicle consists of a neck and a body. The **neck** undergoes elongation, and forms the ductus endolymphaticus. The **body** also undergoes elongation, and its lower portion gives rise to the **cochlea,** whilst its upper portion becomes developed into the **semicircular canals.** The intervening portion of the body becomes partitioned off into the **utricle** and **saccule.** The foregoing structures are all of epiblastic origin.

A periotic cartilaginous capsule is now formed around them, which is ossified from opisthotic, pro-otic, epiotic, and pterotic centres, and gives rise to the **osseous labyrinth.**

The **auditory nerve** is developed from a ridge of epiblast, called the **neural crest,** which is connected on either side with the dorsal aspect of the neural canal.

The **tympanum** and the **Eustachian tube** are developed from the first visceral cleft—that is to say, the cleft between the first or mandibular and second or hyoid arches. At the bottom of this cleft the epiblast and hypoblast meet, and the tympanum and Eustachian tube are developed from the hypoblast.

The **membrana tympani** is developed from the mesoblast which grows between the epiblast and hypoblast at the bottom of the first visceral cleft.

The **meatus auditorius externus** is developed from the epiblast at the bottom of the first visceral cleft.

The **auricle** or **pinna** is developed from certain prominences which make their appearance upon the mandibular and hyoid arches.

The development of the **tympanic ossicles** has been stated in connection with their description.

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GUIDE TO THE HEAD AND NECK.

Back of the Scalp and Neck.—The landmarks having been studied, the skin is to be removed by making the following incisions : one is to be carried along the median line from the level of the seventh cervical spinous process to the vertex of the skull, and this incision may be prolonged to the root of the nose ; a second is to be made from the upper part of the auricle, and a third from the acromial region, both of these meeting the first incision. On reflecting the flaps of skin thus marked out great care has to be exercised, as the skin and superficial fascia are very closely adherent. The cutting edge of the knife should be directed towards the skin, so as to score it, and in doing so the roots of the hairs will be severed. At the same time the dissector will note the strong fibrous processes which bind the superficial fascia to the skin.

The cutaneous nerves are to be displayed at once, and followed to their terminations. The great occipital nerve, with the occipital artery lying external to it, will be met with piercing the complexus, and, it may be, the trapezius, about ½ inch from the median line, and the occipital venous plexus is to be kept in view. The least, or third, occipital nerve, very minute, will be found internal to the great occipital, and the small occipital nerve is to be found along the posterior border of the sterno-cleido-mastoid muscle. The great auricular nerve lies immediately below the small occipital, and turns upwards and forwards over the upper part of the sterno-cleido-mastoid towards the lobule of the auricle, where its mastoid, auricular, and facial branches are to be shown. The superficial or transverse cervical nerve can only be shown initially. It appears immediately below the great auricular, and at once passes horizontally forwards over the sterno-cleido-mastoid, where it must be left in the meantime. The spinal accessory nerve is to be caught where it appears from beneath the posterior border of the sterno-cleido-mastoid, about its centre and below the superficial cervical. It is to be followed downwards and outwards across the posterior triangle to the anterior border of the trapezius, beneath which it disappears. Accompanying it, and lying on a lower level than it, an effort should be made to show the two branches which the anterior primary divisions of the third and fourth cervical nerves furnish to the trapezius. The descending superficial branches of the cervical plexus will be met with at the posterior border of the sterno-cleido-mastoid, immediately below the spinal accessory. If they appear as one trunk they will soon divide into suprasternal, supraclavicular, and supra-acromial ; but these nerves, in this position of the subject, can only be seen at their commencement.

The internal branches of the posterior primary divisions of the third, fourth, and fifth cervical nerves are to be displayed as they pierce the trapezius close to the median line, and they are to be followed outwards.

Behind the auricle, over the mastoid process, the mastoid glands are to be carefully looked for, and the occipital gland, or glands, will be met with over the cranial insertion of the trapezius, or, it may be, the complexus. Along the posterior border of the sterno-cleido-mastoid the glandulæ concatenatæ are to be looked for.

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The cervical part of the trapezius is to be dissected, and its anterior border clearly defined, with the spinal accessory nerve and branches of the third and fourth cervical nerves passing beneath it. The posterior portion of the upper part of the sterno-cleido-mastoid is also to be clearly defined. The interval between the trapezius and the sterno-cleido-mastoid, partially visible in this position of the subject, is the posterior triangle. Within it are to be partially dissected the following structures: a small angle of the complexus muscle pierced by the great occipital nerve, provided the trapezius is not well developed; a portion of the splenius muscle, flat and broad, and directed upwards and outwards; and a portion of the levator anguli scapulæ.

The occipitalis muscle is next to be dissected, and the epicranial aponeurosis, upon which its fibres end, is to be displayed. The close connection between this aponeurosis and the superficial fascia is to be noted, whereas it is only loosely connected to the subjacent periosteum or pericranium. Behind the auricle the retrahens auriculam muscle is to be shown passing between the mastoid process and the convexity of the concha. Lying deeply in the hollow between the mastoid process and the auricle careful dissection will bring into view the posterior auricular nerve and artery, both of which are to be followed to their distribution. The posterior auricular vein is of importance, because, in conjunction with the posterior division of the temporo-maxillary vein, it forms the external jugular vein. Above the auricle the attollens auriculam muscle is to be shown, lying upon the temporal fascia. In front of the auricle, and continuous with the preceding muscle, will be found the attrahens auriculam. The latter two muscles will be found to receive twigs from the temporo-facial division of the facial nerve.

Frontal Region.—The dissection of the frontal region is next to be overtaken, the head being well raised upon a block. The frontalis muscle and front part of the epicranial aponeurosis are to be dissected. The supra-orbital nerve, of large size, is to be carefully displayed. It will be found ascending in line with the junction of the inner third and outer two-thirds of the supra-orbital arch, in company with the supra-orbital artery, and it lies at first beneath the upper part of the orbicularis palpebrarum and the frontalis muscles. Its twigs to the upper eyelid are to be looked for, and its main branches are to be followed towards the vertex of the skull. The supra-trochlear nerve, of small size, will be found internal to the supra-orbital, and in line with the inner canthus of the eye. It is accompanied by the frontal artery. The supra-orbital vein is to be shown passing downwards and inwards to join the frontal vein in the region of the inner canthus, the resultant vessel being the angular vein, which is the commencement of the facial vein. A communicating vessel is to be looked for passing from the supra-orbital vein to the supra-orbital notch, after traversing which it communicates with the superior ophthalmic vein within the orbit.

Temporal Region.—The attollens and attrahens auriculam muscles have been already referred to. Directly in front of the tragus of the auricle there will be found the auriculo-temporal nerve and the superficial temporal artery and vein. The nerve lies between the tragus and the artery, and its meatal, anterior auricular, and temporal branches are to be shown, the first two sets of branches requiring considerable care in their display. The temporal branches of the temporo-facial division of the facial nerve are to be kept in view at this stage. The superficial temporal artery, in two divisions, anterior and posterior, is to be dissected, and special attention is to be given to the tortuous anterior division, which is of some surgical importance. The temporal branch of the temporo-malar or orbital nerve (from the superior maxillary division of the fifth cranial nerve) will be met with piercing the temporal fascia about 1 inch above the anterior part of the zygoma, and close behind the marginal process on the temporal border of the malar bone. Its cutaneous distribution is somewhat limited.

The temporal fascia, or aponeurosis, is next to be dissected. In the region of the zygomatic arch it will be found to consist of two laminæ, between which, in addition to fat, will be found the orbital branch of the superficial temporal artery on its way to the outer part of the orbicularis palpebrarum

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muscle. In removing this fascia the dissector will note that its deep surface gives origin to the superficial fibres of the temporal muscle superiorly. The upper portion of the temporal muscle is then to be studied, but it cannot be followed at the present time beyond the level of the zygomatic arch.

At this stage the dissector, in association with his companion, may take the steps necessary for the removal of the brain, the subject being now assumed to have lain for two days face downwards. It may, however, be preferable to complete the dissection of the back of the neck.

The trapezius is to be divided by a vertical incision about 1 inch from the spines of the vertebræ, in association with the dissector of the upper limb. The spinal accessory nerve is then to be dissected along the deep surface of the muscle, in company with the superficial cervical artery, and the plexiform communication between the spinal accessory and the branches from the anterior primary divisions of the third and fourth cervical nerves is to be shown. The insertion of the sterno-cleido-mastoid is to be in great part detached and turned forwards towards the auricle. Assuming that the dissector of the upper limb has paved the way by dividing and reflecting the rhomboid muscles and the serratus posticus superior, the splenius muscle is then to be fully dissected in co-operation with the dissector of the upper limb. Its twofold condition at its insertion, namely, the splenius capitis and the splenius colli, is to be clearly brought out. The muscle is thereafter to be divided by a vertical incision about 1 inch from the spines of the vertebræ, a procedure which will enable the dissector to display more fully the twofold condition of the muscle at its insertion.

The trachelo-mastoid and complexus muscles fall next to be dissected, the former being very narrow and ribbon-like, whilst the latter is a large and powerful muscle, and is pierced by the great occipital nerve. Tendinous intersections are to be looked for in these muscles, one in each, and in the case of the complexus the condition of its mesial portion is to be carefully looked to. The dissector will note that this portion presents an intervening tendon, with a fleshy belly at either end, thus accounting for the name *biventer cervicis*, by which the inner portion of the complexus is known.

At this stage the second part of the occipital artery falls to be dissected. Its princeps cervicis branch (arteria princeps cervicis) is to be dissected very carefully, and preserved for immediate further dissection. The trachelo-mastoid is to be divided, and the relation of structures in the mastoid region from the surface downwards is to be carefully noted. The complexus is to be divided about 2 inches below its insertion, and on reflecting the muscle the dissector should follow downwards the arteria princeps cervicis. About the level of the spine of the axis he will find that it anastomoses with the deep cervical artery, which, he will note, ascends beneath the complexus. The subsequent and final stage of this dissection consists in displaying the structures of the infra-axial and supra-axial regions. Below the level of the spine of the axis the semispinalis colli muscle, as regards its fourfold insertion, is to be made clear. The origin of this muscle must be dissected in concert with the dissector of the upper limb. Ascending upon it there is, as stated, the deep cervical artery. Passing inwards upon it will be found the internal branches of the posterior primary divisions of the third, fourth, and fifth cervical spinal nerves, whilst those of the sixth, seventh, and eighth nerves pass inwards underneath the muscle. When the semispinalis colli is removed the upper part of the multifidus spinæ falls to be dissected. The interspinales muscles, along with the ligamentum nuchæ, are next to receive attention, and the tendinous slips of insertion of the cervicalis ascendens and transversalis cervicis into tubercles (posterior tubercles) of transverse processes are to be made evident. At this stage the dissector should familiarize himself with the relative position of muscles, proceeding from the tubercles (posterior tubercles) of cervical transverse processes, and passing backwards to the cervical spines.

Above the level of the spine of the axis four muscles and the suboccipital triangle, with its contents, require very careful dissection. The obliquus capitis inferior will be found extending obliquely outwards and upwards from

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the spine of the axis to the transverse process of the atlas, and the dissector will note that the great occipital nerve, preparatory to piercing the complexus, winds round the lower border of the inferior oblique in a backward direction. The obliquus capitis superior will be found extending upwards and inwards from the transverse process of the altas to the occipital bone between the outer parts of the superior and inferior curved lines. The rectus capitis posticus major is to be shown extending from the spine of the axis upwards and outwards to the outer part of the inferior curved line of the occipital bone and the subjacent area. The rectus capitis posticus minor is partially visible internal to the preceding muscle, but is also under cover of it. It will be recognised as a fan-shaped muscle, lying very deeply, and extending from the posterior arch of the atlas, close to the posterior tubercle, in a radiating manner upwards to the inner third of the inferior curved line of the occipital bone and the subjacent area. The suboccipital triangle will now be exposed, lying between the inferior oblique, superior oblique, and rectus capitis posticus major. Within this triangle the dissector, by exercising great care, should expose and study the following structures: (1) the posterior primary division (undivided) of the first cervical or suboccipital nerve, lying in close contact with the vertebrarterial groove of the atlas; (2) the third part of the vertebral artery; (3) the posterior occipito-atlantal ligament (one half), and one half of the posterior arch of the atlas. The suboccipital plexus of veins also occupies this triangle, from which the blood is conveyed away by the vertebral and deep cervical veins.

Up to this stage of the dissection it may be presumed that the period allowed for the subject to lie with its face downwards has expired.

Removal of the Brain.—The brain may be removed whilst the subject lies upon its face, but there is no objection to removing it whilst the subject lies upon its back. The scalp having been previously dissected, together with the temporal fascia and the origin of the temporal muscle, the cranium is to be cleared for the saw by carrying a scalpel around it, passing about 1 inch above the orbits, and about ½ inch above the external occipital protuberance. The external table of the cranial bones is then to be sawn through, and thereafter the internal table is to be cracked by means of a chisel and mallet. The calvaria is then to be eased all round by inserting the chisel, and forcibly raised from the dura mater, which is adherent to it. The dura mater, being now exposed, is to be carefully sponged and studied *in situ*. The superior longitudinal sinus, which runs in an antero-posterior direction in the median line, is to be laid freely open, and its interior examined. On either side of this sinus the outlines of the Pacchionian bodies are to be noted, and the ramifications of the middle meningeal artery are to receive attention.

The dura mater is then to be divided on a level with the sawn margin of the skull, its mesial attachments in front and behind being left intact. On being raised towards the median line, the subdural space will be freely exposed, and the arachnoid membrane and pia mater are to be examined. The cerebral veins, as they pass to the superior longitudinal sinus, are to receive attention, and it should be noted that the direction of these veins is from behind forwards, so that the current of blood in them is opposed to that in the superior longitudinal sinus. The cerebral hemisphere is now to be slightly pulled away from the median line in order to expose the falx cerebri. When this process has been studied, its attachment to the crista galli is to be severed, and the process is to be thrown backwards towards the tentorium cerebelli, after which the brain is to be removed.

Assuming the subject to be lying upon its face, the posterior cerebral lobes are to be raised, which will expose the tentorium cerebelli. This is to be divided near the superior border of the petrous part of the temporal bone, and for a short distance along the course of the lateral sinus on either side, but the sinus is not to be laid open. At the same time the fourth and fifth pairs of nerves are to be divided. Exactly in the median line the vena magna Galeni is to be cut as it is about to enter the straight sinus. The tentorium cerebelli, along with the falx cerebri, is then to be turned backwards, which will expose the cerebellum. The cerebellar hemispheres are next to be care-

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fully raised from the cerebellar fossæ of the occipital bone, and the spinal cord, vertebral arteries, and spinal accessory nerves are to be divided as low down in the spinal canal as possible.

The hypoglossal, pneumogastric, glosso-pharyngeal, auditory, facial, sixth and third nerves are next to be divided, as near as possible to where they leave the cranial cavity. The infundibulum, in the median line, is to be cut, and anterior to it on either side the internal carotid artery is to be divided, along with the optic nerve, which lies directly in front of it. The brain is now to be entirely removed, care being taken to remove along with it the olfactory lobes.

Assuming the subject to be lying upon its back; the mode of procedure will be the reverse of the foregoing.

Before placing the brain in hardening fluid the base of the encephalon is to be carefully studied. Its component parts are to be observed as follows: the medulla oblongata, the pons Varolii, the cerebellum, and portions of the cerebral hemispheres. The crura cerebri will be seen diverging from each other above the pons; anteriorly the optic tracts will be seen to converge and form the optic commissure; and within the enclosed rhomboidal area there will be seen the locus perforatus posticus, the corpora albicantia, the tuber cinereum, and a tag of the infundibulum. The stem of the fissure of Sylvius is to be noted, with the middle cerebral artery traversing it, and the locus perforatus anticus at its inner end. In front of the fissure is the orbital area of the frontal lobe of the cerebral hemisphere, and behind it the prominent temporal lobe. The arachnoid and pia mater are to be carefully examined. Over the gyri they will be found to be in close contact, but in certain situations intervals, called cisternæ, exist between them. These are as follows: (1) cisterna magna, between the cerebellum and the medulla oblongata; (2) cisterna pontis, on the ventral aspect of the pons Varolii, in which the basilar artery lies; and (3) cisterna basalis, over the interpeduncular region, in front of the pons, and containing the circle of Willis. The superficial origins of the cranial nerves, including the olfactory lobe, are to be accurately observed, as well as the arrangement of the arteries. The arteries should be studied in the following order: the two vertebrals, the basilar, the two posterior cerebrals, the trunk of each internal carotid, the two anterior cerebrals, joined by the anterior communicating, the middle cerebrals, and the two posterior communicating arteries. In connection with the foregoing arteries the circle of Willis is to receive careful attention. The anterior and posterior choroidal arteries, as well as the lenticulo-striate arteries, are to be kept carefully in view.

The arachnoid and pia mater are then to be removed as carefully as possible, in order to expose the gyri and sulci to the influence of the hardening fluid. In doing so a gentle stream of water may be advantageous, but the cranial nerves are not to be interfered with, though the arteries may now be taken away. Thereafter the brain, base upwards, is to be carefully packed in a crock containing hardening fluid, and laid aside for future dissection.

Cranial Cavity.—The venous sinuses, cranial nerves, and arteries at the base of the skull are next to be dissected. The superior longitudinal sinus along the upper border of the falx cerebri has been already studied. Along the lower border of the falx cerebri the inferior longitudinal sinus, of small size, is to be followed backwards into the straight sinus, which latter is situated along the line of junction of the falx cerebri and tentorium cerebelli. The occipital sinus is to be shown within the falx cerebelli along the course of the internal occipital crest, as are also the inferior occipital or marginal sinuses on either side of the vermiform fossa. The torcular Herophili is to be laid open. It will usually be found upon the right side of the internal occipital protuberance. The lateral sinus on either side is to receive very careful attention, and in studying it the dissector should make himself familiar with the line, upon the exterior of the head, which indicates its winding course. This sinus should be laid open quite up to the postero-external compartment of the jugular foramen.

The cavernous sinus is then to be dissected with the greatest care, keeping

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in view the third, fourth, ophthalmic, superior maxillary, and sixth nerves, as well as the cavernous sympathetic plexus. Anteriorly the sinus will be found to receive its blood from the orbit through means of the ophthalmic vein or veins. It is connected with its fellow of the opposite side by two venous channels, namely, the anterior and posterior intercavernous sinuses (so-called circular sinus), lying in front of and behind the pituitary body. The cavernous sinus is to be shown dividing posteriorly into the superior and inferior petrosal sinuses. The superior petrosal sinus is to be followed along the superior border of the *pars petrosa* to the point where it opens into the lateral sinus, and the inferior petrosal sinus is to be laid open between the *pars petrosa* and the basilar process of the occipital bone as far as the antero-internal compartment of the jugular foramen, through which it passes independently. The transverse or basilar sinus is represented by several veins arranged in a plexiform manner, and lying over the basilar process of the occipital bone. It forms a connection between the right and left inferior petrosal sinuses.

The cranial nerves are next to receive attention, as they make their exit from the cranial cavity. The olfactory lobes have been removed along with the brain, and the olfactory filaments traverse the foramina in the cribriform plate of the ethmoid bone. Lying upon each half of this plate there is the nasal nerve, accompanied by the anterior ethmoidal artery, both lying beneath the dura mater, and passing forwards and inwards towards the fore part of the side of the crista galli, where they disappear through the nasal slit. The optic nerve will be found at the optic foramen, where it has the internal carotid artery directly behind it. The third, fourth, ophthalmic, superior maxillary, and sixth nerves are to be met with in close relation to the cavernous sinus. The first four of these nerves will be found in relation to the outer wall of the sinus, and the sixth nerve in close contact with the outer wall of the cavernous part of the internal carotid artery within the sinus. The dissection of the cavernous sympathetic plexus, in close relation to the artery, requires considerable care, and the artery itself, with its branches, is to be shown.

The Gasserian ganglion on the large sensory root of the fifth nerve is to be carefully displayed, the small motor root of the nerve lying underneath the ganglion. The locality of the ganglion is the Gasserian depression on the superior surface of the *pars petrosa* near the apex. From the ganglion the ophthalmic nerve is to be followed forwards to the outer wall of the cavernous sinus, the superior maxillary nerve forwards to the foramen rotundum, and the inferior maxillary nerve, along with the motor root of the fifth nerve, downwards to the foramen ovale. At the entrance to the meatus auditorius internus will be found the seventh and eighth nerves, with the internal auditory artery. At the jugular foramen will be found the ninth, tenth, and eleventh nerves, as well as the lateral and inferior petrosal sinuses, and the relative position of the structures at this foramen should receive careful attention. The twelfth nerve will be met with at the anterior condylar foramen, and it is to be noted that it pierces the dura mater in two bundles.

The various structures passing through the foramen magnum must be mastered.

The different meningeal arteries will be found fully described in the text. The sphenoidal fissure and the transmitted structures should be postponed until the dissection of the orbit is being overtaken.

The pituitary body is now to receive attention. It will be found in the pituitary fossa or sella turcica of the sphenoid bone, where it is largely covered by the fold of dura mater called the diaphragma sellæ. If in favourable condition, it should be carefully removed, and studied according to the description given of it in the text.

The interior of the skull, having been carefully cleaned, is now to be protected by placing upon the interior of the base pieces of cotton-wool, soaked in preservative fluid. Thereafter the calvaria is to be replaced, or, if it is not now available for use, the saturated cotton-wool is to be protected from evaporation by the usual means familiar to all.

Side of the Neck.—The subject being now placed with its face upwards,

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it is essential that the dissector should, in the first place, make himself thoroughly familiar with the landmarks of the side and front of the neck, particularly the latter in connection with goitre, laryngotomy, and tracheotomy.

The skin is to be removed by means of the following incisions: a mesial incision is to be carried from the chin to the upper border of the manubrium sterni; another from the lower end of the preceding outwards along the clavicle to the acromion process of the scapula; and a third from the chin along one half of the base of the inferior maxilla to the angle of that bone, and thence to the mastoid region. These incisions have to be made with great care, on account of the thinness of the skin and the important subcutaneous structures.

The muscular sheet, called the platysma myoides, requires very careful dissection, inasmuch as its fasciculi are very pale and delicate, but principally because these fasciculi are embedded in the superficial fascia. Inexperienced dissectors may be surprised when informed that they have removed the muscle in their haste to expose what lies underneath it. The muscle, after examination, is to be reflected from below upwards, and laid over the side of the face. This must be done with the greatest care. Thereafter the following veins are to be dissected, namely, the anterior jugular, near the median line of the neck; the external jugular, crossing the sterno-cleido-mastoid; and the posterior jugular, which is the most external occipital vein. The dissector must be prepared for finding these veins not quite normal. Along the course of the external jugular vein the superficial cervical glands are to be displayed. The nerves which fall to be dissected at this stage are as follows: (1) the great auricular, passing upwards and forwards over the sterno-cleido-mastoid towards the lobule of the auricle; (2) the superficial or transverse cervical, passing forwards over the sterno-cleido-mastoid, and beneath the external jugular vein; and (3) the suprasternal, supraclavicular, and supra-acromial, which three take a downward course. The inframandibular or cervical branch of the facial nerve must also be dissected.

Posterior Triangle.—The dissection of this region should be accomplished in the course of the first four days after the subject has been placed with its face upwards, in order that the dissectors of the neck and upper limb may work in concert. In his mode of procedure the dissector must keep carefully before him the disposition of the deep cervical fascia, which undoubtedly is of a very complicated and, it may be, perplexing nature. But, perhaps, if he masters the description given in the text as a preliminary, it may clear up matters. The boundaries of the posterior triangle are now to be clearly defined, though in the dissection of the back of the neck they would be apparent to a certain extent. The deep cervical fascia, as it extends from the anterior border of the trapezius to the posterior border of the sterno-cleido-mastoid, is to be studied, and its deep expansion to embrace the posterior belly of the omo-hyoid is to be kept in view. This belly is to be at once laid bare and studied. The dissector will note that it divides the posterior triangle into two, a superior or occipital triangle, and an inferior or subclavian (supraclavicular) triangle. The occipital triangle should receive attention first. The structures within it have been already referred to, whilst the subject lay upon its face, *e.g.*, the superficial group of branches of the cervical plexus of nerves, the spinal accessory nerve, the branches from the third and fourth cervical nerves to the trapezius, the glands known as the glandulæ concatenatæ, and the following muscles in part: a small angle of the complexus, provided the trapezius is not well developed at its occipital origin; the splenius capitis; the levator anguli scapulæ; and the scalenus medius. If the posterior border of the sterno-cleido-mastoid be pulled forwards and maintained in that position by hooks, there is no objection to the dissection of the very complicated cervical plexus being partially made at this stage. The dissector, however, must first master the description which is given of the plexus in the text, from which he may see that the evolution of its branches is a complicated process. No hard-and-fast lines

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can therefore be laid down for the guidance of the dissector. He will certainly find the phrenic nerve descending upon the scalenus anticus muscle. Piercing the scalenus medius he should find the following nerves, in order from above downwards: (1) the nerve to the rhomboids; and (2) the upper two roots of the posterior thoracic nerve, or external respiratory nerve of Bell.

The subclavian or supraclavicular triangle now falls to be dissected. Its boundaries will by this time be self-evident, as well as the structures forming, and related to, its roof, in connection with which the supraclavicular glands are to be noted. The third part of the subclavian artery must be carefully dissected, as well as the nerve-trunks of the brachial plexus, all emerging from behind the scalenus anticus muscle. Possibly the posterior scapular artery may be found to arise from the third part of the subclavian. The subclavian vein will not be visible, inasmuch as it lies under cover of the clavicle; neither will the suprascapular vessels. The transverse cervical vessels, however, will be found within the triangle, where the posterior belly of the omo-hyoid is about to disappear beneath the posterior border of the sterno-cleido-mastoid. The relative positions of the upper, middle, and lower nerve-trunks of the brachial plexus to the third part of the subclavian artery are to be made perfectly clear. The formation of the entire plexus is to be made quite manifest. Arising from the front of the upper nerve-trunk will be found the nerve to the subclavius muscle, which is of small size, and descends over the artery and behind the clavicle. The suprascapular nerve, of large size, is to be found arising from the back of the upper nerve-trunk, and taking a course downwards and outwards.

At this stage the dissectors of the head and upper limb should work in concert, and the clavicle and subclavius muscle should be divided about their centre. After a certain amount of dissection an instructive view will be obtained of (1) the continuity between the third part of the subclavian artery and the first part of the axillary; (2) the subclavian vein; (3) the suprascapular vessels; (4) the cords of the brachial plexus; and (5) the infraclavicular branches of the plexus.

Anterior Triangle of the Neck.—The deep cervical fascia is to be dissected as far as possible, without going too deeply at the present stage. The suprasternal space, or space of Burns, is to be examined, and the portion of the deep cervical fascia which extends between the upper part of the anterior border of the sterno-cleido-mastoid and the angle of the inferior maxilla is to be noted. The sterno-cleido-mastoid muscle is to be completely dissected, and its complicated relations studied. The sterno-hyoid, sterno-thyroid, and the anterior belly of the omo-hyoid are also to be dissected, always keeping in view the disposition of the deep cervical fascia. In the dissection of these muscles the descendens cervicis (hypoglossi) nerve is to be exposed. It will be met with either within, or upon, the carotid sheath over the line of the common carotid artery, and in connection with it the loop known as the ansa cervicis (hypoglossi) is to be exposed. It is situated about the centre of the neck, and taking part in it there will be found, coming from behind, a nerve formed by the union of the two rami communicantes cervicis (hypoglossi) from the second and third cervical nerves. These two rami, however, may join the descendens cervicis separately, and before receiving them it parts with its branch to the anterior belly of the omo-hyoid. The loop itself is to be shown furnishing branches to the sterno-hyoid, sterno-thyroid, and posterior belly of the omo-hyoid. The thyro-hyoid muscle is also to be dissected, and the thyro-hyoid branch of the hypoglossal nerve is to be shown entering the muscle beneath its posterior border. Passing beneath this border there will also be found the internal laryngeal nerve and superior laryngeal artery, which here pierce the thyro-hyoid membrane on their way to the interior of the larynx.

The structures along the median line of the neck are to be carefully dissected at this stage, in connection with the operations of laryngotomy and tracheotomy. In doing so the disposition of the deep cervical fascia must be constantly kept in view, and the following groups of lymphatic glands may as well be disposed of at once, namely, the submaxillary lymphatic

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glands, the suprahyoid or submental glands, and the prelaryngeal glands, the latter being met with in the vicinity of the cricoid cartilage, but being sometimes absent. The structures to be attended to along the median line of the neck are as follows, in order from above downwards: (1) the submental triangle; (2) the body of the hyoid bone, with the great cornu on either side; (3) the thyro-hyoid membrane; (4) the isthmus (pomum Adami) of the thyroid cartilage, above which is the well-marked V-shaped thyroid notch, whilst on either side of it is the expanded ala of the thyroid cartilage; (5) the crico-thyroid membrane, largely concealed on either side by the crico-thyroid muscle, and crossed at its centre by the crico-thyroid arterial arch; (6) the narrow anterior part of the cricoid cartilage; (7) the trachea; (8) the isthmus of the thyroid body, usually lying upon the second and third tracheal rings; and (9) the inferior thyroid plexus of veins, from which there pass downwards the right and left inferior thyroid veins. The superficial muscular relations of the trachea are to be carefully noted. The region concerned in laryngotomy is that occupied by the crico-thyroid membrane. The high operation of tracheotomy affects the trachea above the isthmus of the thyroid body, and the low operation is performed upon the trachea below the isthmus. In connection with the latter part of the trachea the dissector should carefully note the following points: (1) its gradually increasing depth; (2) the presence of the inferior thyroid plexus of veins; (3) the relation to it of the innominate and right common carotid arteries; and (4) the possible presence of an arteria thyroidea ima at or close to the median line.

The carotid sheath is next to be dissected, keeping in view that the descendens cervicis (hypoglossi) nerve may lie upon it, or be within it. The sheath will be found to be derived from the posterior lamina of the sheath of the sterno-cleido-mastoid muscle. It is to be carefully opened, having previously noted the sterno-cleido-mastoid artery, and its contents displayed, namely, the common carotid artery, the internal jugular vein, and the pneumogastric nerve, all in separate compartments. Possibly the descendens cervicis nerve may be within it. The contents of the sheath are to be fully dissected, bearing in mind that the gangliated cord of the sympathetic lies close behind the sheath. In dissecting the internal jugular vein the superior and middle thyroid veins are to be borne in mind as tributaries of it, and the deep cervical glands will be found more or less along its course. An effort should be made to expose the carotid body, which will be found behind the common carotid artery close to its bifurcation. On a level with the thyroid attachment of the thyro-hyoid muscle the external laryngeal nerve will be found, which is to be traced downwards to its distribution, chiefly to the crico-thyroid muscle.

The digastric muscle is next to be dissected, along with the stylo-hyoid muscle, which lies above its posterior belly, and the hypoglossal nerve, which lies along its lower border, and here gives off the descendens cervicis and thyro-hyoid nerves. In connection with the V-shaped arrangement of the tendon of the digastric and the hypoglossal nerve, which has now passed beneath the digastric tendon, the triangle of Lesser is to be carefully studied. It contains a portion of the lingual artery, lying under cover of the hyo-glossus muscle. The three subdivisions of the anterior triangle of the neck are now to be reviewed, namely, the muscular (inferior carotid), carotid (superior carotid), and digastric or submaxillary triangles, and their contents noted. The first parts of the external and internal carotid arteries are to be dissected, the former as high as the point where it enters the parotid gland. The anterior branches of the external carotid are to be displayed, namely, the superior thyroid, lingual, and facial, in this order from below upwards. The superior thyroid artery is to be completely dissected, and the following branches of it are to be specially noted, namely, the crico-thyroid artery, and the artery of the isthmus of the thyroid body. The facial artery is only to be dissected as far as the base of the inferior maxilla. Its relation to the submaxillary gland is to be noted, and its cervical branches shown, namely, inferior palatine, tonsillar, glandular, and submental. The lingual artery is, meanwhile, only to be dissected at its origin, and in the first part of its course.

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During the present stage of the dissection the facial vein is to be kept in view; its union with the anterior division of the temporo-maxillary vein to form the common facial vein is to be shown; and the ending of the common facial vein and of the lingual veins in the internal jugular are to be displayed.

The posterior branches of the external carotid, namely, the occipital and the posterior auricular, are also to be fully dissected, and as many of their branches as possible shown. The ascending pharyngeal branch of the external carotid artery is placed too deeply for complete dissection at this stage, but the dissector should bear in mind that it arises from the deep surface of the external carotid near its commencement, and he may expose it by separating the external and internal carotid arteries. The terminal branches of the external carotid, namely, the superficial temporal and the internal maxillary, will be dissected at a later stage in connection with the parotid gland.

At this stage the dissector should direct his attention to the thyroid body. This should be dissected with the greatest care, its lateral lobes and isthmus being clearly defined, together with their blood-supply, the inferior thyroid artery reaching the lateral lobe from below. The not infrequent presence of a pyramidal or middle lobe is to be borne in mind, and in connection with it the fibrous band and levator glandulæ thyroideæ muscle, which pass from its apex to the body of the hyoid bone. When present, it usually springs from the upper border of the isthmus close to the left lobe. The disposition of the thyroid veins is to be noted. The cervical parts of the trachea and œsophagus are also to be fully dissected. The manner in, and the extent to, which the œsophagus projects to the left of the trachea at the root of the neck is to be specially noted, and the inferior or recurrent laryngeal nerve and inferior laryngeal artery are to be carefully displayed as they ascend in the groove between the trachea and œsophagus.

Root of the Neck.—The deep dissection of the root of the neck is now to be overtaken. The scalene muscles—anticus, medius, and posticus—are to be dissected, and their relations are to be carefully noted, more especially those of the scalenus anticus, in connection with which the scalene tubercle or spine (Lisfranc's tubercle) on the inner border of the first rib is to be examined. The first part of the subclavian artery is to be dissected, and its relations mastered. The junction of the internal jugular and subclavian veins to form the innominate vein on either side is to be shown. Opening into the angle of junction of these two veins on the right side the short right lymphatic duct is to be looked for, and on the left side the thoracic duct, the latter arching outwards, forwards, and downwards. The left subclavian artery and the left common carotid at the root of the neck are to be contrasted with the corresponding vessels of the right side, and the differences noted, not only as regards their origins, but also as regards their relations. The right pneumogastric nerve is to be shown crossing the first part of the right subclavian artery, and parting with its recurrent laryngeal branch opposite the lower border of the vessel, that branch turning up behind the artery. The left pneumogastric nerve will be found parallel with the first part of the left subclavian artery, its recurrent laryngeal branch having been given off within the thorax, opposite the lower border of the arch of the aorta. The recurrent laryngeal nerve on either side is then to be followed upwards in the groove between the trachea and œsophagus, in company with the inferior laryngeal artery. The sympathetic loop, known as the ansa Vieussenii, is to be shown in connection with the first part of the subclavian artery, and the sympathetic cord will be found behind it. The branches of this part of the vessel are now to be dissected. The vertebral artery is to be dissected in the first part of its course, and the inferior cervical ganglion of the sympathetic, which lies behind it, is to be kept in view. The mode of termination of the vertebral vein is to be shown. The internal mammary artery is to be followed downwards as far as its entrance upon its thoracic course, and the phrenic nerve is to be shown crossing it superficially from without inwards. The thyroid axis is next to receive attention, and its three branches, namely, inferior thyroid, transverse cervical, and suprascapular,

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are to be dissected. The tortuous course of the inferior thyroid artery inwards behind the lower part of the carotid sheath is to be noted, and its ascending cervical branch is to be shown. The proximity of the middle cervical ganglion of the sympathetic to the artery is to be borne in mind. The suprascapular artery is to be followed outwards, and its medullary branch to the clavicle is to be looked for. The transverse cervical artery, like the suprascapular, above which it lies, is to be followed outwards. The suprascapular and transverse cervical have been in part previously dissected.

The second part of the subclavian artery is to be exposed by dividing and reflecting the scalenus anticus muscle, behind which it lies, whilst the subclavian vein lies in front of that muscle. At this stage the mode of formation of the brachial plexus, and the relations of its nerve-trunks to the subclavian artery are to be revised. The only branch from the second part of the subclavian artery to be dissected is the superior intercostal artery, which, however, usually arises from the first part of the artery on the left side. To see this vessel on the right side it will be necessary to draw the second part of the subclavian artery well forwards and downwards, because the superior intercostal arises from its posterior and upper aspect. Thereafter the vessel descends in front of the neck of the first rib to supply the first and second intercostal spaces, but, before it does so, the deep cervical artery is to be shown arising from it, and taking a backward course between the seventh cervical transverse process and the neck of the first rib. In an earlier stage of the dissection this vessel has been seen ascending upon the semispinalis colli muscle, under cover of the complexus, and anastomosing with the ramus princeps cervicis of the occipital from the external carotid.

The apex of the lung, covered by the dome of the pleura, is to be very carefully noted, and attention is to be given to Sibson's fascia. This fascia will be found to extend from the front of the transverse process of the seventh cervical vertebra to the inner border of the first rib.

Suprahyoid Region.—The dissection of the digastric or submaxillary triangle is now to be overtaken in so far as it can be prior to section of the mandible. The superficial part of the submaxillary gland, of considerable bulk, will first receive attention. Passing downwards over it the dissector will find the facial vein, and more or less embedded in its upper and outer part he will find the facial artery on its way to the face. The superficial part of the gland is to be turned outwards, and kept out of the way by hooks. Thereafter the mylo-hyoid muscle is to be dissected, along with the mylo-hyoid nerve and submental artery resting upon it. The distribution of the mylo-hyoid nerve to the mylo-hyoid muscle and anterior belly of the digastric is to be clearly shown, and the median raphé between the two mylo-hyoid muscles is to be made evident. The posterior border of the mylo-hyoid muscle is next to receive attention. Passing beneath this border will be found, in order from below upwards, the hypoglossal nerve, the deep part of the submaxillary gland, and the lingual (gustatory) nerve. In the back part of the digastric triangle a portion of the parotid gland will be met with, which is separated from the submaxillary gland by the process of the deep cervical fascia known as the stylo-maxillary ligament.

Structures beneath the Mylo-hyoid Muscle.—To expose these structures requires very careful dissection. The mylo-hyoid muscle is to be separated from its fellow along the median raphé, care being taken not to injure the genio-hyoid muscle. It is also to be detached from the body of the hyoid bone, and then the entire muscle is to be reflected upwards towards the mandible. The subsequent steps of this dissection will no doubt be simplified at a later stage when it is in the power of the dissector to divide the mandible at certain points, but no definite hard-and-fast lines can be laid down at this stage. After reflection of the mylo-hyoid muscle the hyo-glossus will be exposed, as well as the stylo-glossus and genio-hyoid. The hyo-glossus is the dissector's landmark. Resting upon its surface he will find the following structures: (1) the hypoglossal nerve, along with the ranine vein, lying close to the hyoid bone; (2) the deep part of the submaxillary gland and Wharton's duct, lying above the hypoglossal nerve; and (3) the lingual nerve, highest

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of all. Between the lingual nerve and the deep part of the submaxillary gland he will, without much difficulty, be able to display the submaxillary ganglion, and show its connections and the branches proceeding from it.

In front of the hyo-glossus muscle the genio-hyo-glossus will be seen, and resting upon it the dissector will find the sublingual gland, to which he should give his attention. The genio-hyo-glossus cannot be dissected in full until the mandible has been divided, and the tongue put upon the stretch by tying its tip to the point of the nose. The following structures passing beneath the posterior border of the hyo-glossus muscle are to be shown, in the following order from above downwards: (1) the glosso-pharyngeal nerve; (2) the stylo-hyoid ligament; and (3) the lingual artery.

The Face.—In the dissection of the face the dissectors of the head should, if possible, dissect in concert. The muscles of expression should be shown upon one side, together with the chief nerves and vessels. On the other side a detailed dissection of all the nerves and vessels is to be made, which will involve the division of certain of the muscles. The frontal and temporal regions having been previously dissected, the skin is to be removed from the face in an outward direction, for which purpose a median incision is to be made from the root of the nose downwards to the symphysis of the inferior maxilla. This incision is to embrace the nostril and one half of the oral aperture. The reflection of the skin will be facilitated by making one or more transverse incisions at the option of the dissector. An incision should also be made around the orbit. The structures already dissected in the frontal and temporal regions are to be revised. The orbicularis palpebrarum is to be dissected by removing the skin very carefully from it in a direction from the circumference to the ciliary margin of each eyelid, along which the skin is to be cut. At the inner canthus the tendo palpebrarum or internal tarsal ligament is to be displayed, and its relation to the lachrymal sac noted. The corrugator supercilii is to be looked for arising from the inner end of the superciliary ridge, and passing outwards and upwards under cover of the frontalis.

The pyramidalis nasi admits of easy dissection as it ascends from the aponeurosis of the compressor naris over the nasal bone to the skin over the glabella. The muscles between the eye, side of the nose, and upper lip are next to be dissected, such as the compressor naris, levator labii superioris alæque nasi, levator labii superioris, depressor alæ nasi, dilator naris anterior, dilator naris posterior, levator anguli oris, and the two zygomatic muscles, major and minor. The risorius of Santorini and the buccinator next fall to be dissected, and in connection with the latter muscle the buccal pad of fat is to receive attention, as well as the buccal lymphatic glands. The muscles between the lower lip and the inferior maxilla come next in order, these being the depressor anguli oris, depressor labii inferioris, and levator menti. The last muscle is most easily shown by (1) everting the lower lip and dividing the mucous membrane in the region of the incisor fossa of the inferior maxilla; and (2) dividing the skin at the median line close down to the bone, but leaving the lower lip uncut. The dissection of the orbicularis oris requires great care. The lips should be well everted, and maintained in this position. The dissector is then to remove the mucous membrane, when the labial mucous glands will be exposed. The deepest stratum of the orbicularis oris is then to be dissected, and an effort made to expose the special muscles which compose it, namely, (1) the musculus incisivus superior, coming from the incisor fossa of the superior maxilla; (2) the musculus naso-labialis, coming from the back part of the nasal septum; and (3) the musculus incisivus inferior, coming from the incisor fossa of the inferior maxilla. The lips being replaced in position, the superficial stratum of the orbicularis oris is to be examined. It will be found to be composed of fibres derived from the elevators and depressors of the angles of the mouth and lips, these fibres stopping at the median line of each lip. The intermediate stratum of the muscle will be seen to consist of buccinator fibres, those of opposite sides being directly continuous at the median line.

The nerves of the face are now to be fully dissected. **The supra-orbital,**

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the supratrochlear, the temporal branch of the orbital or temporo-malar, and the auriculo-temporal have been already dissected. The numerous branches of the temporo-facial and cervico-facial divisions of the facial nerve are to be followed from the parotid gland to their distribution, care being taken to note that the facial is the motor nerve of the buccinator muscle. The infratrochlear branch of the nasal nerve is to be met with in the region of the inner canthus, where it emerges from the orbit below the pulley of the superior oblique muscle. The external terminal branch of the nasal nerve will be found emerging between the lower border of the nasal bone and the upper lateral nasal cartilage, after which it descends beneath the compressor naris muscle to the tip of the nose. The infra-orbital nerve will be found emerging through the infra-orbital foramen, but to display this nerve it is necessary to divide the levator labii superioris muscle. Under cover of this muscle the nerve communicates with the infra-orbital branches of the facial to form the infra-orbital plexus. The inferior palpebral, nasal, and superior labial branches of the infra-orbital nerve are to be followed out. The malar branch of the orbital or temporo-malar nerve will be found emerging through the malar foramen in the malar bone. The long buccal nerve emerges from beneath the anterior border of the masseter on to the buccinator, where its branches communicate with the buccal branches of the facial nerve to form the buccal plexus. The facial branches of the great auricular nerve ramify in the integument over the parotid gland, and send offsets into the gland. The mental nerve will be found emerging through the mental foramen in the inferior maxilla, where it is under cover of the depressor anguli oris, and in line with the interval between the two lower bicuspid alveoli.

The chief arteries to be dissected are the facial and transverse facial. The facial artery is easily found, and is to be followed from the base of the inferior maxilla to the region of the inner canthus. As many of its branches as possible are to be shown, more particularly the two coronary arteries. The position of the facial vein on the outer side of the artery upon the body of the inferior maxilla, in front of the masseter, is to be noted, and a lymphatic gland is to be looked for in this situation. The facial vein will be found to receive a fairly large tributary, the deep facial vein, which comes from the pterygoid plexus, and emerges from behind the anterior border of the ramus of the inferior maxilla and of the masseter muscle. The transverse facial artery will be met with emerging from the anterior border of the parotid gland, after which it crosses the masseter immediately above Stensen's duct. The infra-orbital and mental arteries admit of easy dissection, The other arteries, though numerous, are for the most part of small size, and for them the dissector is referred to the description given of them in the text.

The parotid gland is to be carefully dissected, and all its relations displayed. The strong capsule which invests it, and which is derived from the deep cervical fascia, is to be noted. The lower part of the gland is to be shown occupying the back part of the digastric triangle, where it is separated from the submaxillary gland by the stylo-maxillary ligament. Upon the gland, but beneath the parotid fascia (anterior wall of the capsule), and also within the gland, will be found the parotid lymphatic glands. Emerging from the anterior border of the gland, and passing forwards over the masseter muscle on to the buccinator, the parotid or Stensen's duct is to be shown, with the transverse facial artery above it, and the infra-orbital branches of the facial nerve below it. The pars or glandula socia parotidis is to be shown accompanying Stensen's duct for a variable distance, and lying above it. The branches of the facial nerve are now to be followed into the parotid gland, cutting away the glandular substance in doing so. This will enable the dissector to trace the trunk of the facial nerve to the stylo-mastoid foramen, and to show its posterior auricular, digastric, and stylo-hyoid branches. The auriculo-temporal nerve is also to be shown within the upper part of the gland, and communications between this nerve and the temporo-facial division of the facial, as well as between the great auricular nerve and the cervico-facial division of the facial, are to be kept in view. The external

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carotid artery is to be shown within the gland, dividing into its superficial temporal and internal maxillary branches. The superficial temporal vein is to be followed downwards within the gland until it is joined by the internal maxillary vein, and the resultant vessel, namely, the temporo-maxillary vein, is thereafter to be followed downwards within the gland in front of the external carotid artery. The mode of termination of the temporo-maxillary vein is also to be shown, its anterior division joining the facial vein to form the common facial vein, and its posterior division joining the posterior auricular vein to form the external jugular vein. The foregoing dissections will have led to the removal of a large part of the parotid gland. The dissector will therefore be able to see that it extends inwards behind the ramus of the inferior maxilla, and deeply into the posterior part of the glenoid fossa of the temporal bone.

Ocular Appendages.—The eyelids or palpebræ, with their tarsal plates, are to receive attention, as well as the eyelashes or cilia, and the canthi, outer and inner. At the inner canthus the lacus lacrimalis, caruncula lacrimalis, and plica semilunaris are to be studied, as are also the papillæ lacrimales and puncta lacrimalia. The lachrymal canaliculi are to be opened up, and the lachrymal sac is to be shown lying in the lachrymal groove of the lachrymal bone and nasal process of the superior maxilla. The sac should be laid open, and a probe passed down the nasal duct. The superior and inferior palpebral ligaments, as well as the external tarsal ligament, are to be dissected. The internal tarsal ligament or tendo palpebrarum has been already seen. The conjunctiva, palpebral and ocular, is to be carefully studied, and the superior and inferior fornix noted. On the internal surface of each tarsal plate, between it and the conjunctiva, the outlines of the Meibomian glands will be seen, and their orifices may be visible, arranged in a row a little behind each ciliary margin. In this situation the glands of Moll are to be borne in mind.

Auricle (Pinna).—The auricle is to be carefully studied and dissected. Its extrinsic muscles, namely, attrahens, attollens, and retrahens, auriculam have been already attended to. The component parts of the auricle are to be mastered, namely, the concha, helix, crus helicis, antihelix, tragus, antitragus, incisura intertragica, lobule, tubercle of Darwin, fossa of the helix (scaphoid fossa), and fossa of the antihelix (triangular fossa). The ligaments and intrinsic muscles are to be dissected, according to the description of them which is given in the text; the blood-supply and nerve-supply of the auricle are to be reviewed; and thereafter an effort is to be made to dissect the plate of yellow elastic fibro-cartilage which forms its framework. The meatus auditorius externus is to receive very careful study.

Nose.—The cartilaginous framework of the nose is now to be dissected, and this should be overtaken by the two dissectors working in concert. The upper lateral nasal cartilages will be found immediately below the nasal bones. The lower lateral nasal cartilages, or cartilages of the apertures, are situated below the preceding, and each is bent so as to lie in front, and on each side, of the nostril. The crus laterale and crus mediale of each cartilage of the aperture are to be noted. Two or more sesamoid, or minor, cartilages are to be looked for in the fibrous tissue which connects the crus laterale to the superior maxilla. In dissecting the foregoing cartilages the dissectors should have before them the description given of them in the text. The cartilage of the septum is mesially placed, and can only be fully studied in connection with the interior of the nasal fossæ. It is sufficient meanwhile to note that its anterior border is visible between the anterior borders of the upper lateral nasal cartilages inferiorly.

Masseter Muscle.—Before leaving the dissection of the face the masseter is to be dissected. Its superficial and deep parts are to be clearly shown, and its relations thoroughly mastered.

Orbit.—To prepare the cavity of the orbit for dissection the osseous roof must be removed. For this purpose a vertical cut is to be made with the saw through the frontal bone as low as a point just external to the fovea trochlearis. A second cut is to be made with the saw through the lateral wall of the skull from a point on a level with the auricle downwards and

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forwards to the sphenoidal fissure. A large portion of the malar bone is to be removed, for which purpose the bone-pliers may suffice. In his further mode of procedure the dissector should be careful to leave intact the portion of bone immediately surrounding the optic foramen. The inner and outer saw-cuts are to be connected by using the chisel and mallet, one or two smart knocks being sufficient for this purpose. Thereafter the osseous roof of the orbit is to be tilted forwards by a smart knock with the mallet. The small wing of the sphenoid bone is next to be removed with the bone-pliers. In the foregoing manner the cavity of the orbit will be exposed, and the sphenoidal fissure will be opened from above.

The periosteum of the orbit is to be examined, and then laid open. Exactly in the median line, and embedded in the soft fat of the orbit, the dissector will find the frontal nerve, which anteriorly is accompanied by the supra-orbital artery, and divides into supra-orbital and supra-trochlear. The supratrochlear nerve, before leaving the orbit, will be found to give off a small twig, which descends to form a loop with the infratrochlear branch of the nasal nerve. More deeply placed than the frontal nerve, but also in the median line, the levator palpebræ superioris muscle is to be dissected, and immediately beneath it the superior rectus. The branches of the upper division of the third or oculo-motor nerve to these two muscles are to be found entering the deep or ocular surface of each muscle.

The superior oblique muscle is to be dissected along the inner wall of the orbit, where it lies superficially, and the dissector is to show the fourth nerve entering its superficial or orbital surface far back. The muscle is to be followed forwards, and its tendon traced through the trochlea or pulley, and thereafter to its insertion. Underneath the superior oblique muscle will be found the internal rectus, in dissecting which the branch from the lower division of the third nerve is to be shown entering its deep or ocular surface. Between the superior oblique and internal rectus muscles will be found the nasal nerve and the anterior and posterior ethmoidal vessels. The lachrymal gland will be found at the anterior and outer part of the orbit. The lachrymal nerve, accompanied by the lachrymal artery, is to be found along the outer wall of the orbit, and is to be followed forwards to its distribution. A branch is to be looked for passing downwards from the lachrymal nerve to join the temporal branch of the orbital or temporo-malar nerve. Beneath this nerve the dissector will find the external rectus muscle.

The frontal nerve and levator palpebræ superioris are to be divided, and to facilitate the dissection of the ocular muscles the eyeball may be inflated. This must be done with very great care, in order to leave intact important structures not yet dissected. The optic nerve is to be exposed by carefully pushing aside the yielding structures which cover it. Having slipped a ligature round the nerve not far from the eyeball, a puncture is to be made in the nerve behind the ligature, and a blow-pipe is to be pushed into the nerve as far as its centre. The blow-pipe is then to be pushed forwards into the eyeball, and when the eyeball has been inflated through it the pipe is to be withdrawn, and the ligature made fast. It is possible to destroy the ciliary ganglion in inflating the eyeball, but that ganglion could easily be dissected on the outer side of the optic nerve before taking the steps necessary for inflation.

In the dissection of the ocular muscles the capsule of Tenon is to be kept in view. It forms a connective-tissue covering for the sclerotic coat of the eyeball, and extends from the point of entrance of the optic nerve to near the margin of the cornea, where it joins the ocular conjunctiva. Between the capsule of Tenon and the sclerotic a space can easily be demonstrated by puncturing the capsule, and introducing the handle of a scalpel. This is the perisclerotic space, or Tenon's space. The suspensory ligament of Lockwood requires great care in dissection. It is a thickening of the lower part of Tenon's capsule, and extends between the malar and lachrymal bones. The capsule of Tenon is pierced by the ocular muscles, to which it furnishes sheaths.

In connection with the sheaths of the recti muscles important forward

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expansions are to be noted. Those which are connected with the external and internal recti are strong, and are attached, respectively, to the orbital process of the malar bone and to the lachrymal crest of the lachrymal bone. The expansion connected with the superior rectus blends with the deep layer of the tendon of the levator palpebræ superioris, and that which is connected with the inferior rectus passes to the inferior tarsal plate.

The external rectus muscle is to be fully exposed, with the sixth nerve entering its deep or ocular surface. The two heads of the muscle are to be made quite evident, with the following structures passing between them, in order from above downwards: (1) the upper division of the third nerve, (2) the nasal nerve, (3) the lower division of the third nerve, (4) the sixth nerve, and (5) the ophthalmic vein or veins.

The superior rectus is to be divided and thrown forwards and backwards. On pushing aside and removing a quantity of fat the optic nerve will be exposed, and crossing it from without inwards is the ophthalmic artery. An effort should be made to show the numerous branches of this artery as detailed in the text. The nasal nerve is to be shown crossing the optic nerve from without inwards to the anterior ethmoidal canal, through which it leaves the orbit. The branches of the nerve to be looked for are as follows: (1) the long or sensory root of the ciliary ganglion, which arises from the nasal as it passes between the two heads of the external rectus; (2) two long ciliary nerves, which communicate with the short ciliary nerves, and accompany them; and (3) the infratrochlear nerve. The latter nerve is given off by the nasal at the anterior ethmoidal foramen, and it is to be followed forwards to near the pulley of the superior oblique, where it receives a twig from the supratrochlear nerve. Thereafter it passes beneath the pulley, and emerges from the orbit at the inner canthus. The ciliary or lenticular ganglion will be found on the outer side of the optic nerve. Its long or sensory root will be found coming from the nasal nerve, and its sympathetic root, from the cavernous plexus, usually reaches it through the sensory root. Its short or motor root comes from that branch of the lower division of the third nerve which supplies the inferior oblique muscle. Passing forwards from the ganglion are the short ciliary nerves, which will be seen to range themselves above and below the optic nerve, by which they are conducted to the back part of the sclerotic. The third cranial nerve is to be fully dissected. Its upper and lower divisions are to be shown, and the distribution of their branches made evident, those of the upper division supplying the levator palpebræ superioris and the superior rectus, and those of the lower division supplying the internal rectus, inferior rectus, and inferior oblique. The motor root of the ciliary ganglion comes from the branch to the last-named muscle. The dissector is to note that the branches of the third nerve enter the muscles which they supply on their deep or ocular surface, except in the case of the branch to the inferior oblique, which enters the posterior border of that muscle.

In connection with the origins of the recti muscles the fibrous ring in the region of the optic foramen is to be examined; and its upper part, or superior tendon of Lockwood, and lower part, or ligament of Zinn, are to be noted.

The inferior oblique muscle is situated below the eyeball and also on its outer aspect. In order to expose this muscle the lower eyelid is to be everted, and the conjunctiva divided along the inferior fornix or line of reflection from the lower eyelid on to the eyeball. The origin of the muscle will be found at the anterior and inner part of the floor of the orbit, immediately external to the opening of the lachrymal canal.

The orbital or temporo-malar nerve, which enters the orbit through the spheno-maxillary fissure, is to be looked for in two divisions—temporal and malar. The temporal branch receives a communicating twig from the lachrymal nerve, and ascends upon the outer wall of the orbit to the temporal canal. The malar branch passes forwards in the angle between the outer wall and floor to the malar canal.

During the dissection of the orbit the ophthalmic artery and its branches, as well as the ophthalmic vein or veins, are to be kept in view.

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The structures which pass through the sphenoidal fissure are next to be carefully dissected, and their relative positions noted.

Pterygo-maxillary Region.—The temporal fascia and the part of the temporal muscle above the zygomatic arch have been already dissected. The masseter muscle has also been dissected. In order to expose the pterygo-maxillary region the dissector must proceed in a definite order. The zygomatic arch is to be divided in front of, and behind, the origin of the masseter. This is to be done at first with the saw and then with the bone-pliers. The zygomatic arch, bearing the origin of the masseter, is to be turned downwards until the sigmoid notch of the inferior maxilla is exposed. At this stage the dissector is to show the masseteric nerve and artery emerging from the pterygo-maxillary region over the sigmoid notch and entering the deep surface of the masseter. The nerve and artery having been divided, the masseter is to be stripped from the outer surface of the ramus of the inferior maxilla as low as the angle of the bone. The extensive fleshy origin of the deep part of the muscle from the inner surface of the zygomatic arch is to be carefully noted. The dissector is next to turn his attention to the insertion of the temporal muscle, noting how it extends downwards within the anterior border of the mandibular ramus to the region of the third molar alveolus. The long buccal nerve and the buccal artery are to be caught just within the anterior border of the mandibular ramus as they pass forwards and downwards, or, at all events, they are to be separated from the deep aspect of the insertion of the temporal muscle by pressure with the handle of the scalpel. The coronoid process of the mandible is then to be got rid of by means of the saw and bone-pliers in the following manner : (1) make a vertical cut from the centre of the sigmoid notch downwards for fully ½ inch ; and (2) make a horizontal cut from the anterior border of the mandibular ramus backwards to meet the vertical cut at a right angle. In addition to these cuts through the bone, the strongly tendinous fibres of the temporal muscle must also be divided. The coronoid process, bearing part of the insertion of the temporal muscle, is then to be turned upwards, and the muscle is to be stripped gradually from the lower part of the floor of the temporal fossa. The deep temporal nerves, three in number, are to be looked for, as well as the anterior and posterior deep temporal arteries. An effort should also be made to expose the middle temporal artery, which, being a branch of the superficial temporal, has had to pierce the temporal fascia and temporal muscle to reach the temporal fossa. This artery ascends in the groove familiar to the dissector as marking the outer surface of the squamous part of the temporal bone.

Two other horizontal cuts with the saw and bone-pliers still require to be made through the mandibular ramus. One is to be made immediately below the neck of the inferior maxilla, thus leaving intact the insertion of the external pterygoid muscle. The other cut is to be made across the ramus from its anterior to its posterior border on a level with the summit of the crown of the third or last molar tooth, or, if this tooth be absent, as near that level as possible. This will keep the dissector free of the inferior dental foramen on the inner surface of the ramus, and will consequently leave intact the inferior dental nerve and artery.

The structures to be dissected in connection with the pterygo-maxillary region are as follows : (1) the external and internal pterygoid muscles, the former passing horizontally to the front of the neck of the inferior maxilla, and the latter extending downwards and outwards to the inner surface of the mandibular ramus between the inferior dental foramen and the angle of the bone ; (2) the first and second parts of the internal maxillary artery, the second part of the vessel usually lying upon the external pterygoid muscle, but sometimes passing beneath it ; (3) the pterygoid plexus of veins around the external pterygoid muscle ; (4) the spheno-mandibular ligament (internal lateral ligament of the temporo-mandibular joint), emerging from beneath the external pterygoid muscle and resting upon the internal pterygoid ; (5) the inferior dental and lingual nerves, emerging from beneath the lower border of the external pterygoid and passing downwards, the former, which is posterior in position, parting with its mylo-hyoid branch close to

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the inferior dental foramen ; (6) the long buccal nerve emerging between the two heads of the external pterygoid, and giving upwards the anterior deep temporal nerve ; and (7) the middle deep temporal nerve and the masseteric nerve, emerging from beneath the upper border of the external pterygoid, the latter parting with the posterior deep temporal nerve.

The first and second parts of the internal maxillary artery are to be dissected, as are also the pterygoid muscles. In dissecting the artery the internal maxillary lymphatic glands are to be borne in mind. The first part of the artery will be found to give off (1) the deep auricular, (2) the tympanic, (3) the middle meningeal, furnishing the small meningeal, and (4) the inferior dental, giving off its mylo-hyoid branch. The second part gives off masseteric, deep temporal (anterior and posterior), pterygoid, and buccal branches. The posterior dental artery will be found coming off from the vessel as it is about to enter the spheno-maxillary fossa. The third part of the artery must be deferred to the time when the spheno-maxillary fossa is being dissected.

The inferior dental (with its mylo-hyoid branch) and lingual nerves having been dissected *in situ*, the inferior dental canal is to be laid open, and the inferior dental nerve fully dissected to its distribution. In opening the canal the saw, chisel and mallet, and bone-pliers are to be used. This dissection will show the dissector how the pulps of the lower teeth are supplied with nerves, and it will also make evident the origin of the mental nerve at the level of the mental foramen.

Before reflecting the external pterygoid muscle certain details may be looked to in connection with the temporo-mandibular joint. A complete dissection, however, of this articulation can only be made at the sacrifice of other structures. The dissector is therefore recommended to perform this dissection upon a specially reserved part. He should have little difficulty in studying the external lateral ligament and the capsule. The capsule is to be opened and the interarticular fibro-cartilage noted. This will at once make evident the existence of two synovial membranes, upper and lower. Beyond this the dissector can hardly go, but he should read the description which is given of this joint in the text.

The mandibular condyle is now to be disarticulated and turned forwards, along with the interarticular fibro-cartilage. In this manner the external pterygoid muscle will be reflected ; but, in disarticulating the condyle, the dissector should keep a sharp look-out for the auriculo-temporal nerve, which is in intimate contact with the back of the temporo-mandibular joint. The reflection of the external pterygoid muscle will enable the dissector to expose the following structures : (1) the inferior maxillary division of the fifth cranial nerve and its branches ; (2) the otic (Arnold's) ganglion ; (3) the chorda tympani nerve, passing forwards and downwards, and applying itself to the lingual nerve at an acute angle ; (4) the middle meningeal artery, parting, as a rule, with the small meningeal ; and (5) the upper part of the spheno-mandibular ligament.

The middle meningeal artery will be found to pass, as a rule, between the two roots of origin of the auriculo-temporal nerve. The foregoing structures are to be dissected, as nearly as possible, in agreement with the description which has been given of them in the text. Admittedly the dissector will find the otic ganglion extremely difficult of dissection, but he should not refrain from attempting it. The ganglion lies behind the undivided trunk of the inferior maxillary nerve close to the foramen ovale, and the best plan is to trace upwards the internal pterygoid nerve, with which the ganglion is closely connected.

The pterygo-mandibular ligament is to be examined, which separates the buccinator and superior constrictor muscles, giving origin to fibres of both muscles.

Sublingual Region.—The structures in the submaxillary region have been previously dissected, *e.g.*, the mylo-hyoid muscle, the structures covered by it, the genio-hyoid, and the hyo-glossus. This being so, the dissector is advised to saw through the inferior maxilla, say between the lateral incisor and canine alveoli. This should also be done on the other side by his partner,

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because at this stage it is most desirable that the two dissectors should work in concert. The foregoing cuts will isolate the symphysial portion of the inferior maxilla, and so preserve the attachments of the anterior belly of the digastric, genio-hyoid, and genio-hyo-glossus muscles. By a few touches of the knife the mucous membrane on the inner surface of the mandible can be cut. Thereafter a needle, threaded with a ligature, is to be pushed through the tip of the tongue and through the tip (or columella) of the nose. The needle having now been dispensed with, the ends of the ligature are to be tightly drawn and fixed. The object in this procedure will be at once obvious to the dissector, namely, to put the tongue as much upon the stretch as possible. In the further stages of this dissection the ligature can easily be undone so as to allow the tongue to retire to its normal position. The dissector will now recognise structures which he has been advised to dissect partially at a previous stage. The structures covered by the mylo-hyoid muscle are now to be completely dissected and mastered, namely, (1) the lingual nerve, with the submaxillary ganglion ; (2) the deep part of the submaxillary gland and Wharton's duct ; (3) the hypoglossal nerve ; and (4) the sublingual gland, for the ducts of which the dissector is referred to the text. The genio-hyoglossus muscle now admits of complete dissection, and it will well repay the dissector to study it fully. Immediately external to its extensive insertion into the side of the tongue he should expose the tortuous ranine artery. The genio-hyoid and hyo-glossus muscles have been already referred to. This region is admittedly one of extreme complication and perplexity, so that the dissector should not be surprised that no hard-and-fast instructions can be submitted for his guidance. He may, however, show the stylo-hyoid ligament, the stylo-glossus muscle (already referred to at an earlier stage), the stylo-pharyngeus muscle, and, in connection with that muscle, the glosso-pharyngeal nerve.

The hyo-glossus muscle is to be divided near its origin and reflected towards the tongue. This will expose a portion of the lingual artery, which is now to receive the attention of the dissector, and may be fully studied with advantage. The branches of the vessel are to be dissected in accordance with the text, and special attention is to be directed to the ranine artery.

Superior Maxillary Nerve, Meckel's Ganglion, and Third Part of Internal Maxillary Artery.—This dissection is one of considerable difficulty, and the dissector is advised to have before him for his guidance a section of the skull bearing upon this region. The contents of the orbit having been entirely removed, the skull is to be sawn through in a direction downwards and forwards from a point above the meatus auditorius externus to the region of the inner end of the sphenoidal fissure. This cut will pass through the squamous part of the temporal bone and the great wing of the sphenoid. A second cut with the saw is to be made in advance of the preceding, on a level with the anterior border of the great wing of the sphenoid, and this is to meet the first cut. The portion of bone included between these two cuts is to be removed. The foramen rotundum is to be carefully laid open with the bone-pliers, and the infra-orbital canal is to be opened with equal care. To open the posterior part of this canal the bone-pliers will be sufficient, but the anterior part of the canal, being somewhat deeply placed, will require the saw, or the chisel and mallet. The superior maxillary nerve is now to be studied, its straight course forwards through the foramen rotundum, upper part of the spheno-maxillary fossa, infra-orbital canal and infra-orbital foramen being conspicuous. Its orbital or temporo-malar branch is to be shown, as are also the two short spheno-palatine branches which descend to Meckel's ganglion. A little farther forwards the posterior superior dental nerve is to be shown. This at once divides into two branches which descend upon the zygomatic surface of the superior maxilla. Sometimes these two branches arise separately from the parent trunk. Within the infra-orbital canal, in order from behind forwards, the middle and anterior superior dental branches are to be shown by carefully raising the infra-orbital nerve. The dissector should exercise his own discretion as to the removal of bone to expose the course of these two nerves.

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Meckel's ganglion is now to be dissected. It is suspended from the trunk of the superior maxillary nerve in the spheno-maxillary fossa by means of the two short spheno-palatine nerves, and lies close to the spheno-palatine foramen on the inner wall of the fossa. To understand the course of the branches of this ganglion it is absolutely necessary that the dissector should have an accurate knowledge of the foramina and canals which communicate with the spheno-maxillary fossa. With this knowledge his path will be comparatively smooth, but without it he is certain to become befogged. The spheno-maxillary fossa is so much hemmed in by bone that the dissection of Meckel's ganglion and its branches is one of the nicest dissections in the body. The dissector must act with discretion and osteological knowledge, and he will no doubt clear paths with the bone-pliers which will show the course of the nerves now to be mentioned.

The spheno-palatine nerves have been already shown descending from the superior maxillary nerve to the ganglion, to which they convey sensory fibres. To understand the courses taken by the branches of the ganglion, it may be said that four paths lead from the spheno-maxillary fossa, namely (1) internal, representing the spheno-palatine foramen; (2) inferior, representing the posterior palatine canal and its two byways—the posterior and external accessory palatine canals; (3) posterior, representing (*a*) the Vidian or pterygoid canal and (*b*) the pterygo-palatine canal; and (4) antero-superior, representing the spheno-maxillary fissure. The dissector will now, it is to be hoped, be able to follow the branches of Meckel's ganglion. Taking the **internal path** through the spheno-palatine foramen, he will find (1) the superior nasal nerves, and (2) the naso-palatine nerve, or nerve of Cotunnius, all of which enter the nasal fossa. Traversing the **inferior path** and its two byways, he will find the three descending palatine nerves—great or anterior, small or posterior, and external. In following out the great or anterior descending palatine nerve through the posterior palatine canal the dissector is to show the two inferior nasal nerves which it gives off, and these can be traced without much difficulty to the nasal fossa by removing with the bone-pliers whatever of the vertical plate of the palate bone may be necessary. Pursuing the **posterior paths,** the dissector should look for (1) the Vidian nerve, which takes the Vidian or pterygoid route, and (2) the pharyngeal nerve, which passes through the pterygo-palatine canal. The orbital branch (or branches) of the ganglion takes the **antero-superior path,** and, passing through the spheno-maxillary fissure, enters the orbit.

The branches of the third part of the internal maxillary artery fall in the way of being dissected in the course of the foregoing very complicated dissection. The dissector cannot possibly hope to show everything, so that, to a certain extent, he should rest satisfied with the description given in the text. The posterior dental artery has been already dissected. The infra-orbital artery may be available for dissection. If so, it will have become evident in the course of dissecting the infra-orbital nerve, of which it is the companion in all respects. The spheno-palatine, descending palatine, Vidian, and pterygo-palatine branches may be left with this enumeration of them.

The course of the Vidian nerve, just referred to, may be exposed by removing the portion of bone which lies external to the foramen ovale, and laying open the Vidian canal. Like the preceding dissection, this is one of much nicety. The Vidian nerve, when followed backwards to the region of the foramen lacerum medium, will be found to divide into the great superficial petrosal and great deep petrosal nerves. The great superficial petrosal nerve may be followed beneath the Gasserian ganglion to the hiatus Fallopii, through which it enters the aqueduct of Fallopius to reach the geniculate ganglion of the facial nerve. The great deep petrosal nerve passes to the carotid plexus of the sympathetic.

The foramen ovale may now be laid open and the inferior maxillary nerve, with the motor root of the fifth cranial nerve, exposed. The internal pterygoid nerve is to be shown arising from the back part of the inferior maxillary immediately after the latter has received the motor root, and, in intimate

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relation with that branch of the parent trunk, the otic (Arnold's) ganglion falls to receive consideration. The relation of the ganglion to the small superficial petrosal and auriculo-temporal nerves is to be borne carefully in mind. The ganglion lies immediately below the foramen ovale, between the inferior maxillary nerve and the cartilaginous part of the Eustachian tube, and the middle meningeal artery is situated behind it. The source of the motor root of the ganglion from the nerve to the internal pterygoid muscle will be readily understood, but the dissector must not overlook the small superficial petrosal nerve, which conducts to the ganglion fibres of the glosso-pharyngeal and facial nerves. The cartilaginous part of the Eustachian tube in this vicinity may be made apparent by removing, at the discretion of the dissector, the portion of the great wing of the sphenoid bone which lies internal to the foramen ovale. This dissection will allow of the branches of the otic ganglion being displayed. One branch will be found to pass upwards and backwards to the tensor tympani muscle; a second, downwards and forwards to the tensor palati muscle; branches to the auriculo-temporal nerve; and a branch to the chorda tympani nerve. These, however, are extremely difficult of dissection; nevertheless, an effort made will not be without its reward.

Deep Dissection of the Neck.—A very complicated dissection has now to be overtaken. It is impossible to lay down hard-and-fast instructions for the guidance of the dissector. He is advised to make himself master of what has been carefully stated in the text. The structures referred to are (1) the glosso-pharyngeal, (2) the pneumogastric, (3) the spinal accessory, (4) the hypoglossal, (5) the superior cervical ganglion of the sympathetic, nerves, and (6) the cervical part of the internal carotid artery, along with the upper part of the internal jugular vein. After he has done his best to study these very important structures the dissector is to revise the styloid muscles and ligaments, and thereafter the styloid process of the temporal bone is to be nipped through, and turned downwards and forwards. This procedure may be advisable in the course of the immediately preceding dissection. Without doubt the dissector will find himself in very deep water here. He should, however, try his best. When he gets clear of the difficulties in the upper part of the neck near the base of the skull, his course is fairly clear.

The spinal accessory nerve is to be completely mastered, and its bulbar part, of considerable importance, is to be shown applying itself to the ganglion of the trunk of the pneumogastric. The distribution of the spinal part of the nerve must by this time be familiar to the dissector.

The glosso-pharyngeal nerve is to be followed in accordance with the description which has been given of it in the text.

The ganglion of the trunk of the pneumogastric nerve admits of easy dissection, but must receive careful study. Its pharyngeal and superior laryngeal branches demand most careful attention, and the relation to it of the bulbar part of the spinal accessory nerve is to be specially noted. The pharyngeal branch, conducting fibres of the bulbar part of the spinal accessory, will be found to contribute largely to the pharyngeal plexus, the other contributory nerves being derived from the glosso-pharyngeal and the superior cervical ganglion of the sympathetic. The superior laryngeal nerve has already been followed out in its internal and external laryngeal branches, but the dissector should note that it must contain some of the fibres of the bulbar part of the spinal accessory nerve. The parent trunk of the pneumogastric is now to be carefully studied in its course down the neck. The dissector will be already quite familiar with it. A superior and an inferior cervical cardiac branch are to be kept in view.

As regards (1) the auricular branch of the pneumogastric, colloquially referred to as Arnold's nerve, and (2) the tympanic branch of the glosso-pharyngeal nerve (Jacobson's nerve), the dissector is recommended to accept these as described in the text, unless he desires to pursue a dissection of the most intricate nature possible.

The sympathetic cord is now to be dissected. The superior cervical ganglion, of great length and elliptical shape, can easily be shown, and an effort

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should be made to show all its connections, especially its upward continuation into the carotid canal of the *pars petrosa*. The middle and inferior cervical ganglia will probably have been met with in a previous dissection, the former being associated with the inferior thyroid artery, and the latter with the vertebral artery. From each ganglion, respectively, in order from above downwards, there come the superior, middle, and inferior cervical cardiac branches; but, though these are actually present, the dissector should not feel disheartened if he cannot verify their existence.

Carotid Canal and its Contents.—The dissector is now getting into as deep water as it would be safe for him to enter. His knowledge of osteology should come to his aid. His object is to display the intrapetrous part of the internal carotid artery, and for this purpose he will remove whatever bone he deems desirable. In intimate association with this part of the internal carotid he will find the upward continuation of the cervical sympathetic cord. He may be able to show how this upward prolongation divides into two branches, external and internal, the former giving rise to the carotid plexus, and the latter going on to form the cavernous plexus. The dissector should carefully read the description given of these plexuses in the text.

The foramen lacerum posterius, or jugular foramen, is next to be dissected. Its three compartments, already familiar to the dissector, namely (1) antero-internal, transmitting the inferior petrosal sinus; (2) middle, transmitting the glosso-pharyngeal, pneumogastric, and spinal accessory nerves; and (3) postero-external, transmitting the lateral sinus, may now be completely verified by opening up the foramen referred to.

Pharynx, Soft Palate, and Mouth.—To prepare these important regions for dissection, the skull must be divided into two parts. The leading blood-vessels and nerves, as well as the trachea and œsophagus, are to be divided close to the root of the neck. The pharynx is then to be carefully separated from the prevertebral muscles quite up to the base of the skull, and the basilar region of the skull is to be divided with the chisel and mallet, aided by the saw. The front part of the skull) bearing the pharynx, along with the great bloodvessels and nerves, is to be separated from the back part, which bears the cervical portion of the vertebral column, with the prevertebral muscles. The pharynx having been distended with tow, the superior, middle, and inferior constrictor muscles are to be dissected, and whilst doing so the pharyngeal plexus of veins is to be noted. The manner in which the constrictor muscles overlap one another from below upwards is to be noted. The stylo-pharyngeus muscle and glosso-pharyngeal nerve are to be shown in the interval between the lower border of the superior constrictor and the upper border of the middle constrictor. Upon the surface of the middle constrictor muscle the dissector should make an effort to show the pharyngeal plexus of nerves, formed by the pharyngeal branches of the glosso-pharyngeal and pneumogastric, and branches from the superior cervical ganglion of the sympathetic. Between the lower part of the middle constrictor and upper part of the inferior constrictor there will be found the internal laryngeal nerve and the superior laryngeal artery. The relation of the lower border of the inferior constrictor to the œsophagus is to be noted, and passing beneath this border of the muscle there are the inferior or recurrent laryngeal nerve and artery. The pharyngeal branch of the external carotid artery and the inferior palatine and tonsillar branches of the cervical part of the facial artery may admit of being dissected at this stage, but the injection often fails to enter these arteries. Above the upper border of the superior constrictor muscle the dissector is to note the sinus of Morgagni and the pterygo-mandibular ligament, the latter separating the superior constrictor from the buccinator muscle. The wall of the pharynx, above the superior constrictor muscle, is then to be carefully opened, when the levator palati and tensor palati muscles will admit of dissection.

The dissection of the exterior of the pharynx having been completed, the interior is to be shown by opening the pharynx by means of (1) a median

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vertical incision along its posterior wall, and (2) a transverse incision close to the base of the skull. The soft palate is to be studied, and the divisions of the pharynx noted, namely, the naso-pharynx, above the soft palate, and the buccal and laryngeal divisions below it. In connection with the naso-pharynx the posterior nares and the orifices of the two Eustachian tubes are to receive careful attention. The lateral pharyngeal recess, or fossa of Rosenmüller, on the lateral wall of the naso-pharynx, is to be noted, and the pharyngeal tonsil at the upper and back part, unless the median vertical incision has interfered with it. The pharyngeal bursa, below the pharyngeal tonsil, is also to be examined. The isthmus faucium, superior aperture of the larynx, and œsophagus are next to be examined.

The soft palate is now to receive careful attention. The anterior and posterior pillars of the fauces are to be carefully examined, together with the uvula. The tonsil, lying between the anterior and posterior pillars, is to receive attention, and the supratonsillar fossa may be noted. The actual dissection of the tonsil, however, is to be postponed till the muscles of the soft palate have been dissected. The levator palati and tensor palati muscles are now to be fully dissected. The relation of the levator palati to the membranous floor of the lower part of the Eustachian tube is to be carefully studied. The relation of the tensor palati to the hamular process of the internal pterygoid plate of the sphenoid bone is to be specially noted. The palato-glossus and palato-pharyngeus muscles are to be dissected, and in connection with the latter muscle the salpingo-pharyngeus is to be looked for, descending from the lower part of the cartilage of the Eustachian tube. The dissection of the muscles of the soft palate is to be completed by showing the azygos uvulæ, and the tonsil is then to be dissected.

The mouth is to be carefully examined in detail. Its two divisions, namely, the vestibule and mouth proper, will have been under observation at a previous stage of the dissection. The tongue is to receive very careful attention. At its root will be seen the epiglottis and the folds of mucous membrane in this region, namely, median and two lateral, with the glosso-epiglottidean pouch, or vallecula, on either side of the median fold, are to be noted. The fold, known as the frenum linguæ, should be carefully examined. It will be found on the under surface of the tongue a little distance from the tip. Close to each side of the frenum will be seen a small papilla, bearing the orifice of Wharton's duct, and near to this the orifice of the duct of Rivini or of Bartholin. A little posterior to this is the fold, known as the plica sublingualis, produced by the sublingual gland, and bearing the orifices of the majority of the ducts of Walther (sublingual ducts). In connection with the tongue the three sets of papillæ, namely, conical (and filiform), fungiform, and circumvallate are to be noted. The V-shaped arrangement of the latter will attract notice, and attention is to be given to the foramen cæcum. The limitation of the papillæ to the anterior two-thirds of the tongue will be evident. The extrinsic muscles of the tongue are now to be carefully revised, and their dissection completed if necessary. The intrinsic muscles of the organ fall now to be dissected, namely, the lingualis superficialis, lingualis inferior, lingualis transversus, and lingualis verticalis. The ranine artery having been already dissected, the dissector should revise with the utmost care the nerves which are distributed to the tongue.

Nasal Cavities.—To expose these cavities the skull is to be sawn through vertically on one side of the median line. The septum nasi now admits of full study. Descending upon it, in a forward direction, will be found the naso-palatine nerve, or nerve of Cotunnius, from Meckel's ganglion, and accompanying this nerve may be seen the naso-palatine branch of the spheno-palatine artery. An effort should be made to follow the palatine branch of the naso-palatine nerve through the foramen of Scarpa to the anterior part of the hard palate.

The outer wall of the nasal fossa should be studied with the closest attention. The three meatûs—superior, middle, and inferior—and the three conchæ (turbinate bones) admit of easy examination. The openings into the various meatûs are to be inspected and compared with the descriptions given

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of them in the text. To expose the middle meatus completely the middle concha is to be removed with the scissors. The dissector will then see the deep curved groove, called the hiatus semilunaris, at the upper and anterior part of which will be found the infundibulum. The bulla ethmoidalis will be evident, and the atrium and vestibule are to receive attention. By clipping away the anterior part of the inferior concha a view will be obtained of the lower orifice of the nasal duct, with its imperfect mucous fold, known as the valve of Hasner. The distance of the orifice of the nasal duct from the anterior nasal aperture should be carefully inspected. A probe should be passed through the nasal duct, and the direction taken by the probe noted. A Eustachian catheter should also be passed straight backwards through the inferior meatus, and the mode of introducing it into the lower orifice of the Eustachian tube should be inspected and practised.

The dissection of the otic ganglion and of Meckel's ganglion may now be completely overtaken, it being left to the discretion of the dissector to remove whatever portions of bone may be necessary, after a perusal of the descriptions which are given of these ganglia and their branches in the text.

Larynx.—The larynx, with the tongue, is to be separated from the superior maxilla and the lateral parts of the inferior maxilla. The superior aperture of the larynx and the epiglottis are to be carefully studied, and, on looking down through the superior aperture, the rima glottidis is to be inspected, with a true vocal cord on either side of it. A little above each true vocal cord the less distinct false vocal cord may be seen. In connection with the superior aperture, the cornicula laryngis, or cartilages of Santorini, are to be noted, as well as the cuneiform cartilages, or cartilages of Wrisberg. Between the arytenoid cartilage and the back part of the ala of the thyroid cartilage the recess known as the sinus pyriformis is to be looked for, and its downward direction is to receive attention, which accounts for a foreign body being liable to become lodged within it. The position of the great cornu of the hyoid bone on either side should also receive attention, inasmuch as from an external examination of the upper part of the neck it might possibly be taken for, say, a fish-bone. In the dissection of the larynx, the dissectors, who must act in concert, should keep in view (1) the superior laryngeal nerve, its external, as well as its internal, branch; (2) the inferior or recurrent laryngeal nerve; and (3) the superior and inferior laryngeal arteries; but the latter may not be sufficiently injected for dissection. The internal laryngeal nerve will be found piercing the thyro-hyoid membrane, and the external laryngeal nerve is traceable to the crico-thyroid muscle and the lower part of the inferior constrictor muscle of the pharynx. The recurrent laryngeal nerve will be found close behind the crico-thyroid joint.

The larynx being placed with its posterior surface upwards, the two posterior crico-arytenoid muscles will admit of easy dissection by removal of the mucous membrane. They will be found upon the extensive posterior surface of the cricoid cartilage. The median vertical ridge on the posterior surface of the cricoid cartilage will be found to give origin superiorly to the longitudinal muscular fibres of the œsophagus. In dissecting the arytenoid muscle, which extends between the posterior surfaces of the arytenoid cartilages, the dissector should first show the two decussating arytæno-epiglottidei muscles. To follow out each of these muscles, the outer layer of the aryteno-epiglottidean fold of mucous membrane requires to be carefully removed. The cornicula laryngis may now be shown. They will be found to cap the arytenoid cartilages, and not far from them the cuneiform cartilages may be exposed in the back part of the aryteno-epiglottidean folds of mucous membrane, already familiar to the dissector in connection with the superior aperture of the larynx.

At this stage it may be said that the dissectors cannot possibly expect to obtain anything like a satisfactory knowledge of such an important structure as the larynx from the dissection of one specimen. The larynx should be dissected several times. However, assuming that the time and opportunities of the dissectors are limited, the cricoid and thyroid cartilages may now be studied, followed by the crico-thyroid and crico-arytenoid joints. The thyro-hyoid membrane is to be dissected, and the epiglottis is to be

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examined. The crico-thyroid muscle is to be studied in so far as it can be seen without interfering with the thyroid cartilage, and its nerve-supply, namely, the external laryngeal nerve, is to be carefully noted. The part of the crico-thyroid membrane between the two crico-thyroid muscles has been already studied in connection with the operation of laryngotomy. The larynx being now placed upon its side, the greater part of the ala of the thyroid cartilage is to be removed by making (1) a vertical cut through it not far from the median line, and stopping short of the lower border, and (2) a horizontal cut extending backwards from the lower end of the vertical cut. A complete view will now be obtained of the crico-thyroid muscle, which should be removed. Thereafter the following muscles fall to be dissected, namely, the lateral crico-arytenoid, the thyro-arytenoid, and the thyro-epiglottideus. An effort should be made to show the two portions of the thyro-arytenoid muscle, namely, internal and external; and the close relation of the internal portion to the true vocal cord is to be noted. The lateral crico-arytenoid, and the whole of the thyro-arytenoid, muscles are to be very carefully removed. This will expose the lateral portion of the crico-thyroid membrane, the inferior thyro-arytenoid ligament or true vocal cord, and the wall of the ventricle of the larynx. Above the wall of the ventricle the fibres of the superior thyro-arytenoid ligament, which enter into the false vocal cord, will be found. The mucous membrane above the true vocal cord may now be removed on the side which is being dissected, when the true and false cords of the opposite side may be examined, with the ventricle of the larynx lying between them. The saccule, which is connected with the anterior part of the ventricle, is to be explored with a probe. During the course of the foregoing dissections it is presumed that the dissectors, as recommended, have been keeping in view the nerves and arteries of the larynx.

The ligaments of the larynx will have been displayed in the course of the dissection, these ligaments being the thyro-hyoid membrane, the crico-thyroid membrane, the superior thyro-arytenoid ligament, and the inferior thyro-arytenoid ligament. Two joints require close attention, namely, the crico-thyroid and the crico-arytenoid joints, and the movements allowed at these articulations are to be carefully studied. The varying conditions assumed by the rima glottidis will be found described in the text. The actions of the laryngeal muscles are to be studied with the closest attention, and the function of the epiglottis is to be considered.

Prevertebral Muscles.—The scalene muscles—anticus, medius, and posticus, if not previously dissected, should now be examined, followed by the rectus capitis anticus major, rectus capitis anticus minor, rectus capitis lateralis, and longus colli.

The vertebral artery, as it traverses the costo-transverse foramina of the upper six cervical vertebræ, is to be dissected, and the plexiform arrangement of veins around it is to be noted. The vertebral plexus of the sympathetic is also to be borne in mind.

The Ear.—The meatus auditorius externus is to be laid open with the chisel and bone-pliers, and the membrana tympani is to be carefully examined from the outside. The upper part of the membrane, called the membrana flaccida, or Shrapnell's membrane, which is attached to the notch of Rivini, is to receive special attention. The handle of the malleus will be observed extending between the mucous and fibrous layers of the membrane to a point a little below its centre, where the membrane is drawn inwards so as to give rise externally to a slight depression, known as the umbo. To expose the cavity of the tympanum, an opening is to be made through the thin lamina of bone, called the tegmen tympani, which is situated on the superior surface of the petrous portion of the temporal bone. If this opening is made external to the eminentia arcuata, it will expose the mastoid antrum. The opening is then to be enlarged with the bone-pliers, and the canal containing the tensor tympani muscle is to be laid open. The meatus auditorius internus may also be laid open. The tympanic cavity, with its intricate contents, the tensor tympani muscle, and the osseous part of the Eustachian tube, are now available for examination. The contents of the meatus auditorius internus are to be held over in the meantime. The ossicles of the tympanum, namely,

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the malleus, incus, and stapes, are to be studied *in situ*. The insertions of the tensor tympani and stapedius muscles are to be made evident, and their actions studied. The stapedius muscle will be found to enter the tympanum through an opening on the summit of the pyramid on the posterior wall. The dissector need not expect to be able to show the ligaments of the tympanic ossicles, but he may make an effort to show the chorda tympani nerve. This nerve enters the tympanum through the iter chordæ posterius on the posterior wall. It then passes forwards upon the membrana tympani, lying between its mucous and fibrous layers, and it leaves the tympanic cavity by passing through the iter chordæ anterius, or canal of Huguier, at the inner end of the fissure of Glaser. The inner wall of the tympanum, with the fenestra ovalis, occupied by the foot-piece of the stapes and annular ligament, the promontory, and the fenestra rotunda, closed by the secondary membrane of the tympanum, is to receive careful attention. The dissector may note the position of the attic or epitympanic recess, which lies above the level of the upper margin of the membrana tympani, and which is divided incompletely into two compartments, outer and inner, by the head and neck of the malleus, and the body and short process of the incus. In connection with the outer compartment, he may try and familiarize himself with the pouch of Prussak, which is bounded externally by the membrana flaccida, or Shrapnell's membrane. For the pouches of Troltsch, see the description of the tympanum in the text. The osseous part of the Eustachian tube is to be carefully studied, and the mastoid cells are to be examined. For the latter purpose the mastoid process of the temporal bone is to be laid open.

The internal ear or labyrinth can only be effectually studied from specimens which have been specially prepared. By means of the chisel and bone-pliers, however, the dissector will obtain a fair amount of information regarding this exceedingly complicated region. The meatus auditorius internus having been already laid open, the roof of the labyrinth is to be removed in a fragmentary fashion. The coiled cochlea, with its two and a half turns, is to be noted, its base being directed towards the deep end of the meatus auditorius internus. Behind the cochlea will be found the vestibule, and at the back part of the vestibule the three semicircular canals are to be noted.

Contents of the Meatus Auditorius Internus.—This meatus having been already laid open, the auditory nerve, the pars intermedia of Wrisberg, the meatal portion of the facial nerve, and the internal auditory artery are to be studied. The auditory nerve will be found to break up into two divisions —vestibular and cochlear. The meatal portion of the facial nerve will be found on the upper and anterior aspect of the auditory nerve ; and the pars intermedia of Wrisberg lies between the two. The auditory and facial nerves are connected by two branches. The internal auditory artery is seldom injected.

Facial Nerve in the Aqueduct of Fallopius.—To make a complete dissection of this very intricate aqueduct, the temporal bone requires to be decalcified. An effort should, however, be made to display the aqueduct in the natural bone. The tympanic cavity having been already exposed, the position of the second portion of the aqueduct will be recognised by a ridge on the upper part of the inner wall of the tympanum above the fenestra ovalis. It is here to be laid open with the chisel and mallet. The first portion of the aqueduct, which leads from the deep end of the meatus auditorius internus, may also be laid open with the chisel and mallet in such a manner as to follow the course of the facial nerve, which is horizontally outwards between the cochlea and vestibule to the inner wall of the tympanum. The third or vertical part of the aqueduct, which descends behind the tympanum, to the stylo-mastoid foramen, can best be laid open by removing the mastoid process of the temporal bone. This process is to be sawn across in the vertical-transverse direction, posterior to the level of the stylo-mastoid foramen, into which a probe may be passed for guidance. Another cut is to be made from behind forwards, also in the vertical direction, to meet the preceding cut, close to the stylo-mastoid foramen. The included bone having been removed, the third part of the aqueduct may be reached and laid open with the chisel. In dissecting the facial nerve in the aqueduct, the following structures are to be

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shown: (1) the geniculate ganglion, giving off (*a*) the great superficial petrosal nerve, (*b*) a communicating branch to the small superficial petrosal nerve, and (*c*) the external superficial petrosal nerve (inconstant), all these being situated in the first portion of the aqueduct; and (2) the following branches, arising in the third part of the aqueduct, namely, (*a*) the nerve to the stapedius muscle, (*b*) the chorda tympani nerve, and (*c*) a communicating branch to the auricular branch (Arnold's nerve) of the pneumogastric.

Articulations of the Atlas, Axis, and Occipital Bone.—The ligaments of these joints are to be dissected according to the descriptions given of them in the text, and the movements allowed between the occipital bone and the atlas, and between the atlas and axis, are to be carefully studied. In particular, the following ligaments require special attention: (1) the transverse ligament of the atlas, with the extensive synovial membrane between it and the odontoid process of the axis; (another synovial membrane is to be noted between the odontoid process and the anterior arch of the atlas); (2) the cruciform ligament, of which the preceding forms a part; (3) the lateral odontoid or alar ligaments; and (4) the posterior occipito-axial ligament, or membrana tectoria, which covers the other ligaments just enumerated.

Certain of the ligaments under consideration admit of being dissected from the exterior. These are as follows: (1) the atlanto-axial—anterior, posterior, and capsular; and (2) the atlanto-occipital—anterior, posterior, and capsular. The others, however, are situated within the spinal canal, in relation to its anterior wall. These are as follows: (1) the posterior occipito-axial, or membrana tectoria; (2) the accessory atlanto-axial ligaments; (3) the cruciform ligament, of which the transverse ligament of the atlas constitutes a part; (4) the lateral odontoid or alar ligaments; and (5) the middle odontoid, or suspensory, ligament. In order to display the ligaments which are situated within the spinal canal, the posterior arch of the atlas and the neural arch of the axis should be cut through with the saw. The tabular part of the occipital bone is to be sawn across a little behind the occipital condyles, and the posterior arch of the atlas and the neural arch of the axis are also to be sawn through. After removal of the dura mater, the first ligament to be dissected is the posterior occipito-axial, or membrana tectoria, which, as stated, covers the others, and should be detached from the axis and turned upwards after it has been examined. The cruciform ligament having been studied, the final stage in this intricate dissection consists in detaching the superior crus of the vertical part of the cruciform ligament from the basilar groove of the occipital bone, and turning it carefully downwards.

The Eyeball.—The dissection of the human eyeball can only be accomplished on perfectly fresh specimens. In order to prepare himself for this the dissector is recommended to obtain several eyeballs of the ox, say five or six. The fat, ocular muscles, conjunctiva, and capsule of Tenon are to be removed by dividing, with the scissors, the capsule of Tenon and the conjunctiva in a circular manner at the corneo-scleral junction. The adjuncts of the sclerotic can then be stripped off in a backward direction towards the optic nerve. In detaching the capsule of Tenon from the sclerotic the perisclerotic lymph-space, or Tenon's space, is to be noted. The venæ vorticosæ will probably also be seen. These are usually four in number, and they pierce the sclerotic about midway between the optic entrance and the corneo-scleral junction, at points equally distant from each other. Near the corneo-scleral junction the anterior ciliary arteries may be seen piercing the sclerotic, and around the entrance of the optic nerve the ciliary nerves and posterior ciliary arteries may be seen piercing the sclerotic.

It is well that the eyeballs should be prepared for dissection by keeping them in a 10 per cent. solution of formalin, which may sufficiently harden them. There being several ox's eyeballs at the disposal of the dissector, it will be to his advantage to make use of two of them in the following manner: (1) divide one eyeball into two halves, inner or nasal, and outer or temporal, by making an antero-posterior cut along the sagittal axis, or axis of vision—that is to say, a line connecting the anterior and posterior poles of the eyeball; and (2) divide another eyeball into two halves, anterior and posterior, by making a cut along the course of the equator. These two sections

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will afford the dissector a general knowledge of the component parts of the eyeball.

Upon another ox's eyeball the sclerotic and cornea are to be examined. The sclerotic is to be carefully opened at a point in the course of the equator down to the level of the chocolate-coloured choroid. Thereafter the sclerotic is to be clipped completely round the eyeball in the course of the equator, which will divide it into two parts—anterior and posterior. These two parts are then to be carefully reflected, one forwards and the other backwards, which may be facilitated by clipping each into flaps. The dark brown tint of the inner surface of the sclerotic is to be noted, this being due to the connective-tissue layer, called the lamina fusca. Processes passing from the lamina fusca to the subjacent choroid coat will have been observed, these processes traversing the perichoroidal lymph-space.

The sclerotic having been removed in the foregoing manner, the dissector will now obtain a view of the choroid or vascular coat, easily recognised by its chocolate colour. If the dissector can succeed in washing out the pigment from the choroid, he may obtain a view of the closely-set, whorled venæ vorticosæ, which converge to four points, and form four vessels. These vessels will then present a white appearance.

Ciliary Process.—Upon another ox's eyeball a vertical-transverse section is to be made, anterior to the line of the equator. The posterior segment is to be laid aside in the meantime, for the examination of the posterior half of the retina. The vitreous body having been removed from the anterior segment, a good view will be obtained, from behind, of the ciliary processes, which radiate from the periphery of the crystalline lens.

Iris.—To obtain a view of the iris, and also of the ciliary processes, from before, the cornea is to be clipped in another eyeball around the corneo-scleral junction, and removed. This opens up the anterior part of the aqueous chamber, and the iris can now be examined. The shape of the pupil in the ox's eye is to be noted, it being much elongated in the transverse direction.

Flaps of the anterior part of the sclerotic are then to be made with the scissors, by clipping from before backwards, and thereafter they are to be turned backwards. This may enable the dissector to obtain some knowledge of the ciliary muscle, which may be recognised as a white ring in the region of the corneo-scleral junction. In front of the ciliary muscle is the canal of Schlemm. To demonstrate the canal of Petit a blow-pipe may be introduced, close to the periphery of the crystalline lens, through the posterior layer of the zonula of Zinn, behind the ciliary processes (see the text). By blowing air in, the canal of Petit may become evident, and it may then present a sacculated appearance. The suspensory ligament of the lens will be recognised as lying in front of the canal of Petit.

Crystalline Lens.—The iris having been removed, the anterior wall of the capsule of the crystalline lens is to be laid open, when the lens will escape. The outer portion of the lens will be felt to be soft, but the central portion, which constitutes the nucleus, is of firm consistence.

The posterior segment of the eyeball, recently laid aside, is now to be examined by carefully removing the vitreous body. This will enable the dissector to examine the posterior part of the retina from the front.

The foregoing dissections having been made upon the ox's eyeballs, the dissector should avail himself of the first opportunity of repeating them upon the human eyeball. For this purpose the eye of a child will suffice, or a human eye may possibly be obtained from the post-mortem room of a hospital.

The Spinal Cord.—To expose the spinal cord within the spinal canal, the vertebral and sacral grooves of the vertebral column are to be cleaned as well as possible by scraping away the muscles which occupy them. The laminæ of the vertebræ, having been thereby exposed, are to be sawn through on either side in an inwardly slanting direction, and the ligamenta subflava, which connect the laminæ, are to be divided. The chisel and mallet should also be used in this dissection. This will enable the dissector to remove the posterior wall of the spinal canal, which will be available for the dissection

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of the ligamenta subflava, and the interspinous and supraspinous ligaments. The spinal canal having been laid open, the dissector will expose the epidural space, occupied by loose areolar tissue, embedded in which there is a copious plexus of veins and spinal arteries. The arteries of the spinal canal and spinal cord, though usually uninjected, are to be studied from the description given of them in the text, and, in association with the arteries, the veins are to receive attention.

Meninges of the Cord.—The dura mater, forming the theca, the arachnoid, and the pia mater, are to receive the most careful attention. The outer surface of the dura mater will be readily exposed by removing the areolar tissue and plexus of veins already referred to. The dissector will easily be able to show the tubular sheaths which the dura mater furnishes on either side to the spinal nerves as these pass through it, these sheaths being prolonged into the intervertebral foramina.

The dura matral theca is now to be carefully laid open along the middle line with a pair of scissors. This will expose the narrow interspace known as the subdural space. This space having been studied, attention is to be directed to the arachnoid membrane, beneath which is a wide interspace, called the subarachnoid space. In studying this space the dissector is to make himself familiar with its division into three compartments by means of the septum posticum, posteriorly, and the ligamenta denticulata, one on either side. The arachnoid membrane having been carefully removed, the pia mater is to be studied. Its very intimate relation to the spinal cord will be at once evident, and in connection with it the ligamenta denticulata, right and left, should receive careful attention. The manner in which the ligamenta denticulata act as suspensory ligaments to the spinal cord will be evident.

The spinal cord, along with the dura mater, is now to be removed from the spinal canal. In doing so the dissector should be careful to remove, at the same time, the lateral prolongations of the dura mater into the intervertebral foramina, containing the spinal nerves. For this purpose the intervertebral foramina may be laid open with the bone-pliers, and the actual dissection of a spinal nerve may be accomplished at this stage, if the dissector prefers it.

The external characters of the cord are then to receive the most careful attention. The glistening band, called the linea splendens, is to be noted on the anterior surface of the cord, over the course of the anterior median fissure. The cervical and lumbar enlargements are to be noted. The mode of origin of a spinal nerve by two roots is to be made evident, and the ganglion on the posterior root is to be shown. The union of the two roots immediately outside the ganglion, to form a spinal nerve, should be shown, as well as the division of the spinal nerve into anterior and posterior primary divisions. The anterior median and posterior median fissures, as well as the postero-lateral sulcus, are to receive attention. The antero-lateral and posterior columns are to be studied, as well as the columns of Goll and of Burdach. At the lower end of the cord the conus medullaris will be seen, and the arrangement of nerves, known as the cauda equina, will attract attention, in the centre of which leash the filum terminale can be shown without difficulty.

When the dissector has studied the external characters of the cord. he should endeavour to harden it by immersion in the ordinary fluid used for the preservation and hardening of the brain. This process will occupy three or four weeks, after which time transverse sections should be made through the cord at various levels. This will give the dissector some knowledge of the internal structure of the cord.

The Brain.—The brain, it is assumed, has been sufficiently hardened by immersion in the fluid used for this purpose. In their operations upon this organ it is absolutely necessary that the dissectors should treat it with the most scrupulous gentleness, supporting it on all sides where necessary, and always keeping those parts which are not under immediate dissection or observation covered with cloth saturated with the hardening fluid. With these general precautions the brain should be placed on a wooden platter,

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the base being at first downwards, and a kind of nest having been made for it on the platter with pieces of cotton wadding, saturated with the hardening fluid. Two small wedge-shaped blocks should also be in constant use, each being insinuated gently underneath the lateral aspect of the corresponding cerebral hemisphere. These blocks the dissectors will find to be of great utility in keeping the parts of the brain together.

The superior surface of the brain is to receive the most careful attention, and the dissectors are recommended to study the description given of it in the text.

The brain is now to be reversed, and placed in its nest with the base upwards. In doing so it must be handled with the greatest gentleness. The dissectors have been already advised to study the base immediately after the removal of the brain from the cranial cavity. It will, however, well repay them to renew this examination in view of the importance of the parts here exposed for their careful study, *e.g.*, (1) the component parts of the encephalon; (2) the superficial origins of the cranial nerves, including the olfactory lobes; (3) the arteries, including the circle of Willis; (4) the cisternæ beneath the arachnoid, and so on (see the description given of all these in the text).

A careful effort may be made to follow out the leading arteries, but this is on no account to be pushed, as, to do so, might endanger structures of considerable importance. The branches of each vertebral artery may admit of reasonable dissection; so also may those of the internal carotid. The dissectors will find a description of the arteries in the text, and their special attention is drawn to the lenticulo-striate arteries. If the fissure of Sylvius has not been already opened up, that should now be carefully done, in order to see the gyri operti of the insula or island of Reil, lying deeply at the bifurcation of the fissure.

The bloodvessels and membranes are now to be carefully removed from the base of the brain, except in the interval between the cerebellum and medulla oblongata. For this purpose the forceps will be sufficient, aided occasionally by a pair of scissors. In doing so there is considerable risk of taking away the cranial nerves, but this must not be done. The interpeduncular region may now be studied, and the superficial origins of the cranial nerves revised, the olfactory lobe also receiving attention.

The dissectors are now advised to reverse the position of the brain, and to proceed with a systematic dissection of all its parts; but they must be prepared to encounter considerable difficulties, as it is not an easy matter to lay down hard-and-fast directions. It may be further stated that the brain should be dissected several times, and in different ways.

The brain being now placed with its base downwards, the fissures, lobes, and gyri of the cerebral hemispheres, in so far as they are visible, are to be thoroughly mastered, special attention being directed to (1) Broca's lobe; (2) the fissure of Rolando, and the gyri which bound it in front and behind; (3) the parieto-occipital fissure; and (4) the three limbs of the fissure of Sylvius. The opercula insulæ are also to be studied.

The cerebral hemispheres are then to be sliced away with a long knife until the level of the corpus callosum is reached. In doing so the dissector is to note the white matter in the centre, surrounded by the grey cortex. The corpus callosum is to be carefully inspected from above, the raphé, striæ longitudinales mesiales, and striæ longitudinales laterales being noted. The anterior cerebral arteries will also be seen sweeping backwards upon the corpus callosum. The forward and backward extent of the corpus callosum is also to be attended to.

Lateral Ventricles.—These ventricles are to be opened by means of two longitudinal cuts through the corpus callosum, each cut being made about ½ inch from the median line. Each ventricle is then to be laid completely open, so as to show the anterior and posterior cornua, by removing as much of the hemisphere as may be necessary. The various structures exposed in the floor of the lateral ventricle are to be carefully studied, namely, (1) the nucleus caudatus of the corpus striatum in the anterior cornu; (2) the tænia semicircularis, and the vein of the corpus striatum; (3) a portion of the

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upper surface of the optic thalamus, resting upon which there are (*a*) the sharp lateral border of the fornix, and (*b*) the choroid plexus of the lateral ventricle; and (4) the bulb of the posterior cornu, produced by the fibres of the forceps major, and beneath this the calcar avis, or hippocampus minor, produced by the anterior calcarine fissure on the mesial surface of the cerebral hemisphere.

The middle or descending cornu of the lateral ventricle, situated within the temporal lobe, is to be laid freely open by removing a large portion of that lobe. The remarkable course of this cornu is to be noted, and the following structures, which occupy its floor, are to be studied: (1) the hippocampus major, or cornu Ammonis; (2) the fimbria, or tænia hippocampi; (3) the eminentia collateralis, or pes accessorius; and (4) the choroid plexus of the descending cornu. The swelling in which the hippocampus major terminates, called the pes hippocampi, is to be noted; and the choroidal fissure which extends from the foramen of Monro to the lower extremity of the descending cornu is to receive attention.

The corpus callosum is now to be divided transversely about its centre. On raising the anterior part the septum lucidum will be exposed, as it extends vertically between the under surface of the corpus callosum and the upper surface of the body of the fornix. The relation of the septum lucidum to the lateral ventricles having been studied, the septum is to be carefully divided with a pair of scissors, and the interval between its two layers, called the fifth ventricle, or ventricle of the septum, is to be examined. It will be evident to the dissectors that this ventricle is a closed space.

The posterior part of the corpus callosum may now be turned backwards.

The fornix falls to be studied at this stage. Thereafter it is to be divided transversely about its centre, and the two parts are to be carefully raised from the subjacent velum interpositum, and turned forwards and backwards. The two posterior pillars of the fornix will be seen to be at first connected with the under surface of the corpus callosum, but subsequently each enters the descending cornu of the lateral ventricle under the name of the fimbria, or tænia hippocampi. On the under surface of the corpus callosum, between the diverging posterior pillars of the fornix, the dissector is to note the lyra, or psalterium. On turning forwards the anterior part of the fornix, its two anterior pillars will be seen descending towards the base of the brain, and in the interval between them a partial view will be obtained of the anterior commissure. After reflection of the fornix the velum interpositum is exposed, in connection with which the two veins of Galen are to be studied, these subsequently joining to form the vena magna Galeni. The transverse fissure of the brain, by which the pia mater enters, to form the velum interpositum, may be studied at this stage, its lateral portions being the choroidal fissures.

Third Ventricle.—To expose this ventricle at the present stage the velum interpositum is to be removed with the greatest care. It is to be laid hold of with the forceps anteriorly, and turned backwards. In doing so the two choroid plexuses of the third ventricle on the under surface of the velum interpositum, as well as the ependymal roof of the third ventricle, are necessarily removed. In reflecting the back part of the velum interpositum the dissector must be careful not to disturb the pineal body, which rests upon the mesencephalon at the back part of the ventricle. This dissection will expose fully (1) the upper surface of each optic thalamus; (2) the chink-like cavity of the third ventricle, lying in the mesial line between the two optic thalami; and (3) the middle, or grey, commissure, which extends between the inner surfaces of the optic thalami. This commissure, however, being very soft, often gives way. At this period the dissectors should make themselves familiar (by revision) with the various structures which form the roof of the third ventricle. This ventricle itself is to be fully studied, and the relation of its sloping floor to the interpeduncular region at the base of the brain is to be carefully noted. The optic thalamus is to be studied, and in connection with it the following parts are to be noted: (1) the anterior tubercle; (2) the posterior tubercle, or pulvinar; (3) the corpus geniculatum externum; and (4) the stria pinealis, or medullaris, as well as the sulcus of

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Monro, on its internal surface. The anterior pillars of the fornix and the anterior commissure are to be again looked to. The two foramina of Monro are to receive careful consideration, each being situated between the anterior pillar of the fornix in front and the anterior tubercle of the optic thalamus behind. It will be evident to the dissectors that the third ventricle communicates freely with the two lateral ventricles by means of the foramina of Monro. If attention is now directed to the posterior part of the third ventricle, the dissectors will see the upper opening of the aqueduct of Sylvius, by which aqueduct the third ventricle communicates with the fourth ventricle. Above the upper opening of this aqueduct, and beneath the stalk of the pineal body, the dissectors will have no difficulty in seeing the posterior commissure.

Pineal Body.—This body is situated upon the mesencephalon at the posterior part of the third ventricle, and should receive careful attention. In connection with it the following parts are to be noted : (1) the stalk, peduncle, or habenula, the dorsal portion of which forms the stria pinealis, or medullaris, already referred to in connection with the internal surface of the optic thalamus ; (2) the pineal recess, which passes backwards above the posterior commissure into the stalk, or habenula, of the pineal body (but this recess, like the optic, infundibular, and suprapineal recesses, can best be studied from plaster, or metal, casts of a mesial section through the brain) ; and (3) the trigonum habenulæ, which will come more fully into view presently.

Mesencephalon, or Mid-brain.—The mid-brain may be exposed from above by displacing backwards the anterior part of the cerebellum until the corpora quadrigemina are sufficiently exposed. This should be done with the greatest care, in order not to injure (1) the valve of Vieussens, immediately below the lower pair of quadrigeminal bodies, with the superior peduncle of the cerebellum on either side ; and (2) the slender fourth cranial nerves, which issue from the valve of Vieussens, and thereafter turn round the crura cerebri, one on either side.

The corpora quadrigemina now fall to be studied. They will easily be recognised as four rounded eminences, arranged in pairs, upper and lower, and the crucial groove which separates them from one another will attract attention. The internal geniculate body will be recognised as a small oval mass on the lateral aspect of the mesencephalon, under cover of the pulvinar of the optic thalamus. The superior and inferior brachia are to be examined, also upon the lateral aspect of the mesencephalon. A reference to the text may guide the dissectors in their examination of these brachia.

At this stage the dissectors are advised to read the description of the optic tract and its connections as given in the text. They are to make themselves familiar with the mesial and lateral roots of the optic tract, and are to note very carefully that (1) the pulvinar of the optic thalamus, (2) the external geniculate body, and (3) the upper quadrigeminal body constitute the lower visual centres, as distinguished from the higher, or cortical, visual centre in the cortex of the cuneate and lingual gyri close to the calcarine fissure on the mesial surface of the occipital lobe. The trigonum habenulæ, previously referred to, will now be fully exposed.

To complete the dissection of the mesencephalon the crura cerebri are to receive the most scrupulous attention at this stage, and it will be necessary to carefully reverse the preparation for this purpose—at all events, for revision.

The mesencephalon is now to be divided transversely between the upper and lower pairs of quadrigeminal bodies. This procedure will enable the dissectors to remove the following parts, namely, the pons Varolii, cerebellum, and medulla oblongata. On examining the cut surface the aqueduct of Sylvius will be seen in section. The division of each crus cerebri into two by the crescentic mass of grey matter, called the substantia nigra, may be evident, the upper or dorsal part being the tegmentum, and the lower or ventral part the crusta or pes. The oculo-motor sulcus on the inner surface of the crus for the third or oculo-motor nerve is to be noted, and on the outer surface will be seen the lateral sulcus. The description given of the crus cerebri in the text is to be carefully read.

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Basal Ganglia of the Cerebral Hemispheres.—The pons Varolii, cerebellum, and medulla oblongata are to be laid aside in the meantime, and the dissection of what is left of the cerebral hemispheres is to be overtaken. This should be divided into two parts by a mesial, antero-posterior incision, and one of these parts is to be used for the examination of the inferior surface of the cerebral hemisphere. (The mesial surface of the cerebral hemisphere should be studied on another brain.) In this connection the orbital surface of the frontal lobe will fall to be examined, with its olfactory sulcus, triradiate sulcus, and gyri. The inferior surfaces of the temporal and occipital lobes will also admit of being examined.

The basal ganglia are then to be attended to, these being the nucleus caudatus and nucleus lenticularis of the corpus striatum, the claustrum, and the amygdaloid nucleus. Several sections through the cerebral hemispheres require to be made to obtain a knowledge of these important ganglia. On one side coronal, that is to say, vertical-transverse sections are to be made through the cerebral hemisphere from the level of the front part of the nucleus caudatus backwards to the posterior part of the optic thalamus. On the other side several horizontal sections are to be made through the structures which lie upon the floor of the lateral ventricle. In connection with these sections the dissectors are advised to read the description given of the basal ganglia, and also of the optic thalami, in the text.

Medulla Oblongata.—The dissectors are to note carefully the superficial origins of the seventh, eighth, ninth, tenth, eleventh, and twelfth cranial nerves. The anterior median fissure, with the pyramid on either side, is to be examined, and an effort is to be made to show the decussation of the pyramids. The olivary body and anterior superficial arcuate fibres are to receive attention. In connection with the posterior area of the medulla oblongata it is to be noted that it is divided into two portions, lower or closed, and upper or open. The lower portion presents in the median line the posterior median fissure, on either side of which are the following structures, in order from within outwards: (1) the funiculus gracilis, which is the continuation of Goll's column of the spinal cord, and which terminates superiorly in the clava; (2) the funiculus cuneatus, or continuation of Burdach's column of the spinal cord, terminating superiorly in the cuneate tubercle; and (3) the funiculus of Rolando, terminating superiorly in the tubercle of Rolando. The calamus scriptorius, between the two clavæ, is to be noted; but the upper or open part of the medulla had better be postponed until the floor of the fourth ventricle is under consideration. Suffice it to say that it presents on either side the restiform body. The dissectors should at this stage make themselves familiar with the cisterna magna, in connection with the subarachnoid space, this cisterna lying between the cerebellum and the medulla oblongata. Further dissection of the medulla oblongata should only be overtaken with proper assistance.

Pons Varolii.—This will admit of easy examination, except as regards its dorsal surface and internal structure. The points to be noted are as follows: (1) the basilar groove; (2) the crura cerebri, emerging from its upper part; (3) the middle peduncles, emerging from it laterally; (4) the stout sensory, and slender motor, roots of the fifth cranial nerve, also emerging from it laterally; and (5) the sixth, seventh, and eighth cranial nerves at its lower border. The dorsal surface of the pons is to be postponed for a short time, until the floor of the fourth ventricle is under examination.

Cerebellum.—Like other parts of the encephalon, the cerebellum requires to be examined from several points of view. Assuming, however, that the dissectors desire to get as much as possible out of one brain (a desire to be strongly deprecated), the component parts of the cerebellum are to be studied. On the superior surface the superior vermis and the upper surface of each hemisphere are to be examined. On the under surface the vallecula is to be noted, with the inferior vermis lying deeply in it. In connection with the inferior vermis the following parts are to be studied: (1) the tuber valvulæ; (2) the pyramid; (3) the uvula, with the furrowed band on either side of it, covered by the amygdala; and (4) the nodule, with the lateral portion of the inferior medullary velum on either side of it. On the under surface of each

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cerebellar hemisphere the following parts are to be noted: (1) the postero-inferior lobule, composed of (*a*) the lobulus gracilis, and (*b*) the inferior semilunar lobule; (2) the biventral lobule; (3) the amygdala; and (4) the flocculus.

The dissectors should also make themselves familiar with the peduncles of the cerebellum, namely, the superior, middle, and inferior peduncles, right and left. The superior peduncles will be seen to converge towards the lower pair of quadrigeminal bodies, after they emerge from the cerebellar hemispheres, the valve of Vieussens having been already observed extending between them. The middle peduncles, formed by the transverse fibres of the pons Varolii, sink into each cerebellar hemisphere. The inferior peduncles, which constitute the restiform bodies, connect the cerebellar hemispheres with the upper or open part of the medulla oblongata posteriorly.

Fourth Ventricle.—This ventricle is to be laid open by making a median incision through the vermis of the cerebellum from above. This will bring into view the central collection of white matter called the corpus trapezoides. The two parts of the cerebellum are then to be gently separated, so as to expose the superior medullary velum, or valve of Vieussens, the inferior medullary velum, and the tela choroidea inferior, which lies lower down than the inferior medullary velum, and presents in the median line the foramen of Magendie. The obex is to be looked for in the lower part of the roof, where it overhangs from behind the upper opening of the central canal of the spinal cord, and on either side the ligula may be seen projecting over the epithelium of the roof for a short distance. When these structures have been divided, the floor of the fourth ventricle will be exposed. Its rhomboidal shape is to be noted. At the lower end the dissectors will observe the opening of the central canal of the spinal cord and the calamus scriptorius, and at the upper end the lower opening of the aqueduct of Sylvius. The longitudinal groove, traversing the floor between these two openings, is to be noted, and the striæ acusticæ crossing the floor towards its centre, on either side of this groove, are to receive attention. The floor is thus divided into two portions, lower and upper. The lower or medullary portion will be seen to be bounded on either side, from below upwards, by the clava, the cuneate tubercle, and the restiform body, which latter should now receive full consideration. The parts to be noted in connection with each half of the lower portion of the floor are as follows: (1) the fovea inferior, (2) the trigonum vagi, (3) the trigonum hypoglossi, and (4) the trigonum acusticum. The trigonum acusticum may be seen to be continued superiorly into a prominence called the tuberculum acusticum, over which the striæ acusticæ pass.

The upper or pontine portion of the floor will be seen to be bounded on either side by the superior peduncle of the cerebellum, and the parts to be noted in connection with each half are as follows: (1) the fovea superior; (2) the eminentia teres, produced by the subjacent fasciculus teres; (3) the locus cæruleus; and (4) an upward prolongation of the tuberculum acusticum.

The lateral recess of the fourth ventricle is to be examined. It will be found as a lateral prolongation of the ventricle, on either side, round the upper part of the restiform body. In the roof of each lateral recess is the foramen of Kay and Retzius.

The great horizontal fissure of one cerebellar hemisphere is now to be opened up, and the upper half of the hemisphere is to be removed. This will give the dissectors a view of the three cerebellar peduncles as they enter the white medullary substance in the centre of the hemisphere. This substance contains the corpus dentatum, which is a wavy lamina of grey matter enclosing white matter, and open at the upper and inner part. Through this opening many of the fibres of the superior cerebellar peduncle emerge. To expose the corpus dentatum a cerebellar hemisphere has to be cut through horizontally a little above the level of the centre. Sagittal sections are also to be made across the direction of the cerebellar laminæ, when the appearance known as the arbor vitæ cerebelli will become evident.

Lastly, with proper assistance, sections should be made through the pons Varolii, with the view of obtaining some knowledge of its internal structure.

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APPENDIX.

ANATOMICAL NOMENCLATURE.

OSTEOLOGY.

(Skeletal System).

Vertebral Column.

ENGLISH.	LATIN.
Odontoid facet of **Atlas.**	Fovea dentis.
Axis.	Epistropheus.
Lateral mass of **Sacrum.**	Pars lateralis.
Auricular surface of ,,	Facies auricularis.

Thorax.

False, or asternal, **Ribs.**	Costæ spuriæ.
Ensiform process of **Sternum.**	Processus xiphoideus.
Interclavicular notch of ,,	Incisura jugularis.

Bones of the Head.

Occipital Bone.	**Os Occipitale.**
Anterior condylar foramen.	Canalis condyloideus.
Jugular process.	Tuberculum jugulare.
Superior curved line.	Linea nuchæ superior.
Inferior ,, ,,	,, ,, inferior.
Groove for lateral sinus.	Sulcus transversus.

Parietal Bone.	**Os Parietale.**
Internal surface.	Facies cerebralis.
Posterior border.	Margo occipitalis.
Anterior ,,	,, frontalis.
Superior ,,	,, sagittalis.
Inferior ,,	,, squamosus.
Parietal eminence.	Tuber parietāle.

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ENGLISH.	LATIN.
Frontal Bone.	**Os Frontale.**
Frontal eminence.	Tuber frontale.
Superciliary ridge.	Arcus superciliaris.
Supra-orbital arch.	Margo supra-orbitalis.
External angular process.	Processus zygomaticus.
Temporal Bone.	**Os Temporale (Temporis).**
Fissure of Glaser.	Fissura petrotympanica.
Glenoid fossa.	Fossa mandibularis.
Articular eminence.	Tuberculum articulare.
Mastoid Portion.	*Pars Mastoidea.*
Digastric groove.	Sulcus mastoideus.
Petrous Portion.	*Pars Petrosa.*
Aqueduct of Fallopius.	Canalis facialis.
Gasserian depression.	Impressio trigemina.
Vaginal process.	Vagina processûs styloidei.
Aqueduct of the cochlea.	Canaliculus cochleæ.
Eustachian canal.	Semicanalis tubæ auditoriæ.
Sphenoid Bone.	**Os Sphenoidale.**
Pituitary fossa.	Fossa hypophysea.
Olivary eminence.	Tuberculum sellæ.
Carotid groove.	Sulcus caroticus.
Sphenoidal turbinate bones.	Conchæ sphenoidales.
Optic groove.	Sulcus chiasmătis.
External pterygoid plate.	Lamina lateralis.
Internal ,, ,,	,, medialis.
Eustachian groove.	Sulcus tubæ auditoriæ.
Ethmoid Bone.	**Os Ethmoidale.**
Lateral mass.	Labyrinthus ethmoidalis.
Os planum, or orbital plate.	Lamina papyracea.
Superior Maxillary Bone.	**Maxilla.**
Orifice of the antrum.	Hiatus maxillaris.
Lachrymal groove.	Sulcus naso-lacrimalis.
Nasal process.	Processus frontalis.
Malar process.	,, zygomaticus.
Incisor canal.	Canalis incisivus.
Alveolar border.	Limbus alveolaris.
Malar Bone.	**Os Zygomaticum.**
Malar canal.	Canalis zygomatico-orbitalis.
Lachrymal Bone.	**Os Lacrimale.**
Hamular process.	Hamulus lacrimalis.

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ENGLISH.	LATIN.
Inferior Turbinate Bone.	**Concha Inferior.**
Palate Bone.	**Os Palāti.**
Inferior turbinate crest.	Crista conchalis.
Superior ,, ,,	,, ethmoidalis.
Inferior Maxillary Bone.	**Mandibula.**
Condyle.	Processus condylaris.
Sigmoid notch.	Incisura mandibularis.
Inferior dental foramen.	Foramen mandibulare.
Hyoid Bone.	**Os Hyoideum.**
The Teeth.	
Teeth.	**Dentes.**
Ivory.	Substantia eburnea.
Enamel.	,, adamantĭna.
Nasmyth's membrane.	Cuticula dentis.
Dental arch.	Arcus dentalis.
Wisdom tooth.	Dens serōtĭnus.
Bones of the Upper Limb.	
Humerus.	**Humerus.**
Bicipital groove.	Sulcus intertubercularis.
Radius.	**Radius.**
Bicipital tuberosity.	Tuber radii.
Sigmoid cavity.	Incisura ulnaris.
Ulna.	**Ulna.**
Great sigmoid cavity.	Incisura semilunaris.
Hand.	**Manus.**
Carpus.	**Carpus.**
Scaphoid bone.	Os naviculare manûs.
Semilunar bone.	Os lunatum.
Cuneiform or pyramidal bone.	Os triquetrum.
Pisiform bone.	Os pisiforme.
Trapezium.	Os multangulum majus.
Trapezoid.	Os multangulum minus.
Os magnum.	Os capitatum.
Unciform bone.	Os hamatum.
Thumb.	Pollex.
Index finger.	Index.
Middle ,,	Digitus medius.
Ring ,,	,, minimo-proximus vel annularis.
Little ,,	Digitus minimus.

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Bones of the Lower Limb.

ENGLISH.	LATIN.
Hip-bone.	**Os Coxæ.**
Articular surface of acetabulum.	Facies lunāta.
Cotyloid notch.	Incisura acetabuli.
Ilium.	*Os Ilii.*
Ilio-pectineal line.	Linea arcuata.
Ischium.	*Os Ischii.*
Os Pubis.	*Os Pubis.*
Pubic spine.	Tuberculum pubĭcum.
Pelvis.	**Pelvis.**
Brim.	Apertūra superior.
Outlet.	,, inferior.
Femur.	**Os Femoris.**
Depression for ligamentum teres.	Fovea capitis.
Outer lip of linea aspera.	Labium laterale.
Inner ,, ,, ,,	,, mediale.
Popliteal surface.	Trigōnum femoris.
Foot.	**Pes.**
Tarsus.	**Tarsus.**
Scaphoid bone.	Os naviculare pedis.
Great toe.	Hallux.
Sinus pedis.	Sinus tarsi.

ARTHROLOGY.

(Articulations or Joints).

(L. = Ligamentum).

Vertebral Column.

Intervertebral discs.	Fibro-cartilagines intervertebrales.
Circumferential fibro-laminar part of disc.	Annulus fibrosus.
Central pulp of disc.	Nucleus pulposus.
Anterior common ligament.	L. longitudinale anterius.
Posterior ,, ,,	L. ,, posterius.
Occipito-atlantal ligaments.	Membrānæ atlanto-occipitales.

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ENGLISH.	LATIN.
Lateral odontoid, or alar, ligaments.	Ligamenta alaria.
Middle odontoid ligament.	L. apicis dentis.
Cruciform ligament.	L. cruciatum.

Thorax.

Anterior costo-central, or stellate, ligament.	L. capitis costæ radiatum.
Interarticular ligament.	L. capitis costæ interarticulare.
Middle costo-transverse ligament.	L. cervicis costæ.
Anterior and posterior costo-sternal ligaments.	Ligamenta sterno-costalia radiata.

Upper Limb.

Interarticular meniscus.	Discus articularis.
Suprascapular ligament.	L. transversum scapulæ superius.
Spino-glenoid ligament.	L. transversum scapulæ inferius.
Glenoid ligament of **shoulder-joint.**	Labrum glenoidale.
Internal lateral ligament of **elbow-joint.**	L. collaterale ulnare.
External lateral ligament of **elbow-joint.**	L. collaterale radiale.
Pisi-uncinate ligament.	L. piso-hamatum.
Pisi-metacarpal ligament.	L. piso-metacarpāle.

Pelvis.

Great sacro-sciatic ligament.	L. sacro-ischio-tuberans.
Small ,, ,,	L. sacro-ischio-spinosum.
Inferior or subpubic ligament.	L. arcuatum.
Interpubic disc.	Lamina fibro-cartilaginea interpubĭca.

Lower Limb.

Cotyloid ligament of **hip-joint.**	Labrum glenoidale.
Pubo-femoral ligament.	L. pubo-capsulare.
External lateral ligament of **knee-joint.**	L. collaterale fibulare.
Internal lateral ligament of **knee-joint.**	L. collaterale tibiale.
Mucous ligament (*ligamentum mucosum*).	Plica synovialis patellaris.
Alar ligaments.	Plicæ alares.

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MYOLOGY.

(Muscular System).

(M. = Musculus).

Muscles of the Back.

ENGLISH.	LATIN.
Complexus.	Semispinalis capitis.

Muscles of the Upper Limb.

Serratus magnus.	M. serratus anticus.
Biceps flexor cubiti.	M. biceps brachii.
Brachialis anticus.	M. brachialis.
Triceps extensor cubiti.	M. triceps brachii.
Long head of ,, ,,	Caput longum.
External ,, ,, ,,	,, laterale.
Internal ,, ,, ,,	,, mediale.
Pronator radii teres.	M. pronator teres.
Supinator radii longus.	M. brachio-radialis.
Supinator radii brevis.	M. supinator.

Muscles of the Lower Limb.

Quadriceps extensor cruris.	M. quadriceps femoris.
Vastus externus.	M. vastus lateralis.
Crureus.	M. ,, intermedius.
Vastus internus.	M. ,, medialis.
Subcrureus.	M. articularis genŭs.
Biceps flexor cruris.	Biceps femoris.
Flexor, or musculus, accessorius.	M. quadratus plantæ.

Muscles of the Abdomen.

Poupart's ligament.	Ligamentum inguinale.
Gimbernat's ligament.	,, lacunare.
Triangle of Petit.	Trigōnum lumbale.

Muscles of the Thorax.

Triangularis sterni.	M. transversus thorācis.
Foramen quadratum of diaphragm.	Foramen venæ cavæ inferioris.

Muscles of the Head.

Epicranial aponeurosis.	Galĕa aponeurotica.
Compressor naris.	M. nasalis transversus.
Dilator alæ nasi.	M. ,, alaris.

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ENGLISH.	LATIN.
Depressor alæ nasi.	M. depressor septi.
Orbicularis palpebrarum.	M. orbicularis oculi.
Tensor tarsi.	Pars lacrimalis musculi orbicularis oculi.
Depressor labii inferioris.	M. quadratus labii inferioris.
Palato-glossus.	M. glosso-palatīnus.
,, pharyngeus.	M. pharyngo-palatinus.
Azygos uvulæ.	M. uvulæ.
Lingualis superficialis.	M. longitudinalis superior.
,, inferior.	M. ,, inferior.

ANGEIOLOGY.

(Vascular and Lymphatic Systems).

Heart.	Cor.
Auriculo-ventricular groove.	Sulcus coronarius.
Antero-superior surface.	Facies sterno-costalis.
Inferior surface.	,, diaphragmatica.
Vestigial fold of Marshall.	Ligamentum venæ cavæ sinistræ.
Auricle.	*Atrium.*
Interauricular septum.	Septum atriorum.
Columnæ carneæ.	Trabeculæ carneæ.
Annulus ovalis.	Limbus fossæ ovalis.
Foramina Thebesii.	Foramina venarum minimarum.
Tubercle of Lower.	Tuberculum intervenosum.
Eustachian valve.	Valvula venæ cavæ inferioris.
Thebesian valve.	,, sinûs coronarii.
Interventricular Septum.	*Septum Musculare Ventriculorum.*
Pars membranacea.	Septum membranaceum ventriculorum.
Tricuspid Valve.	*Valvula Tricuspidalis.*
Right cusp.	Cuspis medialis.
Left or infundibular cusp.	,, anterior.
Posterior or septal cusp.	,, posterior.
Mitral Valve.	*Valvula Mitralis vel Bicuspidalis.*
Semilunar or Sigmoid Valves.	*Valvulæ Semilunares.*
Corpus Arantii.	Nodulus valvulæ semilunaris.

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ENGLISH.	LATIN.
Arteries.	**Arteriæ.**
(A. = Arteria vel Arteriæ).	
Pulmonary artery.	A. pulmonalis.
Arch of the Aorta.	Arcus Aortæ.
Right coronary artery.	A. coronaria dextra.
Left ,, ,,	A. ,, sinistra.
Innominate artery.	A. anonyma.
Common carotid artery.	A. carōtis communis.
External Carotid Artery.	**A. Carōtis Externa.**
Ranine artery.	A. profunda linguæ.
Facial ,,	A. maxillaris externa.
Inferior coronary artery.	A. labialis inferior.
Superior ,, ,,	A. labialis superior.
Internal Maxillary Artery.	**A. Maxillaris Interna.**
Vidian artery.	A. canalis pterygoidei.
Circle of Willis.	Circulus arteriosus.
Subclavian Artery.	**A. Subclavia.**
Internal mammary artery.	A. mammaria interna.
Superior phrenic artery.	A. pericardiăco-phrenica.
Thyroid axis.	Truncus thyreo-cervicalis.
Suprascapular artery.	A. transversa scapulæ.
Axillary Artery.	**A. Axillaris.**
Superior thoracic.	A. thoracalis suprēma.
Acromio-thoracic artery.	A. thoraco-acromialis.
Long thoracic artery.	A. thoracalis lateralis.
Dorsalis scapulæ artery.	A. circumflexa scapulæ.
Anterior circumflex artery.	A. circumflexa humeri anterior.
Posterior ,, ,,	A. ,, ,, posterior.
Brachial Artery.	**A. Brachialis.**
Superior profunda artery.	A. collateralis superior.
Inferior ,, ,,	A. ,, media.
Anastomotic artery.	A. ,, inferior.
Radial Artery.	**A. Radialis.**
Superficial volar artery.	A. volaris superficialis.
Anterior radial carpal artery.	A. radialis carpea volaris.
Radialis indicis artery.	A. radialis volaris indicis.
Ulnar Artery.	**A. Ulnaris.**
Common interosseous artery.	A. interossea communis.
Anterior ,, ,,	A. ,, volaris.
Posterior ,, ,,	A. ,, dorsalis.

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ENGLISH.	LATIN.
Anterior ulnar carpal artery.	A. ulnaris carpea volaris.
Posterior ,, ,,	A. ,, ,, dorsalis.
Profunda artery.	A. volaris profunda.
Superficial palmar arch.	Arcus volaris superficialis.
Deep palmar arch.	Arcus ,, profundus.
Abdominal Aorta.	**Aorta Abdominalis.**
Capsular arteries.	A. suprarenales.
Spermatic ,,	A. spermaticæ internæ.
Cœliac axis.	A. cœliaca.
Gastric (coronary) artery.	A. gastrica sinistra.
Splenic Artery.	**A. Lienalis.**
Vasa brevia.	A. gastricæ breves.
Hepatic Artery.	**A. Hepatica.**
Pyloric artery.	A. gastrica dextra.
Superior Mesenteric Artery.	**A. Mesenterica Superior.**
Rami intestini tenuis.	A. intestinales.
Right colic artery.	A. colica dextra.
Middle ,, ,,	A. ,, media.
Inferior Mesenteric Artery.	**A. Mesenterica Inferior.**
Left colic artery.	A. colica sinistra.
Sigmoid arteries.	A. sigmoideæ.
Internal Iliac Artery.	**A. Hypogastrica.**
Gluteal artery.	A. glutæa superior.
Sciatic ,,	A. ,, inferior.
Artery of the vas deferens.	A. deferentialis.
Internal Pudic Artery.	**A. Pudenda Interna.**
Superficial perineal artery.	A. perinæi.
Artery of the bulb.	A. bulbi urethræ.
,, ,, corpus cavernosum.	A. profunda penis vel clitoridis.
External Iliac Artery.	**A. Iliaca Externa.**
Deep epigastric artery.	A. epigastrica inferior.
Cremasteric artery.	A. spermatica externa.
Femoral Artery.	**A. Femoralis.**
Anastomotic artery.	Arteria suprema genūs.

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ENGLISH.	LATIN.
Popliteal Artery.	**A. Poplitea.**
Superior external articular artery.	A. superior lateralis genūs.
Superior internal articular artery.	A. ,, medialis ,,
Middle or azygos articular artery.	A. media genūs.
Inferior external articular artery.	A. inferior lateralis genūs.
Inferior internal articular artery.	A. ,, medialis ,,
Lower muscular or sural arteries.	A. surales.
Plantar Arteries.	**A. Plantares.**
Internal plantar artery.	A. plantaris medialis.
External ,, ,,	A. ,, lateralis.
Dorsal Artery of Foot.	**A. Dorsalis Pedis.**
Tarsal artery.	A. tarsĕa lateralis.
Metatarsal artery.	A. arcuata.
Veins.	**Venæ.**
	(V. = Vena vel Venæ).
Great cardiac or coronary vein.	V. magna cordis.
Small cardiac, or right conorary, vein.	V. parva ,,
Middle cardiac vein.	V. media ,,
Smallest cardiac veins.	V. minimæ ,,
Innominate veins.	V. anonymæ, dextra et sinistra.
Vena azygos major, or Right azygos vein.	V. azygos.
Vena azygos minor inferior, or Lower left azygos vein.	V. hemi-azygos.
Vena azygos minor superior, or Upper left azygos vein.	V. ,, accessoria.
Facial vein.	V. facialis anterior.
Temporo-maxillary vein.	V. ,, posterior.
Common facial vein.	V. ,, communis.
Portal vein.	V. portæ.
Splenic vein.	V. lienalis.
Internal iliac vein.	V. hypogastrica.
Internal or long saphenous vein.	V. saphēna magna.
External or short ,, ,,	V. ,, parva.
Sinuses of the Dura Mater.	**Sinŭs Duræ Matris.**
	(S. = Sinus).
Superior longitudinal sinus.	S. sagittalis superior.
Inferior ,, ,,	S. ,, inferior.
Straight sinus.	S. rectus.
Circular ,,	Sinŭs intercavernosi.
Basilar ,,	Plexus basilaris.
Lateral ,,	S. transversus.
Cavernous sinus.	S. cavernosus.

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ENGLISH.	LATIN.
Lymphatic System.	**Systēma Lymphaticum.**
Thoracic duct.	Ductus thoracicus.
Receptaculum chyli.	Cisterna chyli.
Right lymphatic duct.	Ductus lymphaticus dexter.

NEUROLOGY.

(The Nervous System).

Spinal Cord.	**Medulla Spinalis.**
Cervical enlargement.	Intumescentia cervicalis.
Lumbar ,,	,, lumbalis.
Anterior column.	Funiculus anterior.
Lateral ,,	,, lateralis.
Posterior ,,	,, posterior.
Column of Goll.	,, gracilis.
,, Burdach.	,, cuneatus.
Anterior cornu.	Columna grisea anterior.
Posterior ,,	,, ,, posterior.
Lateral ,,	,, ,, lateralis.
Central canal.	Canalis centralis.
Clarke's column.	Nucleus dorsalis.

Tracts in the Spinal Cord.

Tract of Goll.	Funiculus gracilis.
,, Burdach.	,, cuneatus.
Direct cerebellar tract.	Fasciculus dorso-lateralis cerebello-spinalis.
Tract of Gowers.	Fasciculus antero-lateralis cerebello-spinalis.
Pyramidal tract, lateral or crossed part.	Fasciculus cerebro-spinalis lateralis.
Pyramidal tract, anterior or direct part (column of Türck.)	Fasciculus cerebro-spinalis anterior.
Antero-lateral descending cerebellar tract.	Fasciculus cerebello-vestibulo-spinalis.
Anterior ground-bundle.	Fasciculus anterior proprius.
Lateral ,, ,,	,, lateralis proprius.

Encephalon.

Bulb.	**Medulla Oblongata.**
Pyramid.	Pyramis.
Olivary body or eminence.	Corpus olivare vel Oliva.
Restiform Body.	Corpus Restiforme.
Fillet.	Lemniscus.

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ENGLISH.	LATIN.
Decussation of the Fillets.	Decussatio lemniscorum.
Superior medullary velum (Valve of Vieussens).	Velum medullāre superius vel anterius.
Inferior medullary velum.	Velum medullāre inferius vel posterius.
Red nucleus.	Nucleus ruber.
Superior quadrigeminal bodies.	Colliculi superiores.
Inferior ,, ,,	,, inferiores.
Stratum cinereum.	Stratum griseum.
Aqueduct of Sylvius.	Aquæductus cerebri.
Crusta or Pes of the Crus Cerebri.	Basis pedunculi.
Pineal body.	Corpus pineāle.
Ganglion habenulæ.	Nucleus habenulæ.
Middle or grey commissure.	Commissūra mollis.
Corpora albicantia.	Corpora mammillaria.
Bundle of Vicq d'Azyr.	Fasciculus thalamo-mammillaris.
Optic tract.	Tractus opticus.
Optic commissure.	Chiasma opticum.
Nucleus of Luys.	Corpus subthalamicum vel Nucleus hypothalamicus.
Great longitudinal fissure.	Fissura interhemispherica.
Fissure of Sylvius.	Fissura lateralis.
Fissure of Rolando.	Sulcus centralis.
Quadrate lobule of Parietal Lobe.	Præcuneus.
Island of Reil.	Insula.
Threshold of the Island of Reil.	Limen insulæ.
Convolution of the Corpus Callosum.	Gyrus fornicatus.
Limbic Lobe.	Gyrus fornicatus et gyrus hippocampi.
Uncus.	Uncus gyri hippocampi.
Hippocampus major.	Hippocampus.
Dentate Gyrus.	Fascia dentata hippocampi.
Lyra or Psalterium.	Commissura hippocampalis.
Cuneate Lobule.	Cuneus.
Radiation of the Corpus Callosum.	Radiatio corporis callosi.
Forceps minor.	Pars frontalis.
Forceps major.	,, occipitalis.
Anterior pillars of the Fornix.	Columnæ fornĭcis.
Posterior ,, ,, ,,	Crura fornĭcis.
Septum lucidum.	Septum pellucidum.
Lateral Ventricles.	**Ventriculi Laterales.**
Anterior horn.	Cornu anterius.
Middle or Lateral horn.	,, inferius.
Posterior horn.	,, posterius.

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ENGLISH.	LATIN.
Third Ventricle.	Ventriculus tertius.
Fourth Ventricle.	Ventriculus quartus.
Fifth Ventricle.	Ventriculus quintus vel Cavum septi pellucidi.
Meninges.	**Meninges.**
Epidural space.	Cavum epidurale.
Subdural ,,	,, subdurale.
Subarachnoid space.	,, subarachnoidale.
Pacchionian Bodies.	Granulationes arachnoidales.

Cerebro-spinal Nerves.

(N. = Nervus vel Nervi).

Cranial Nerves.	N. Cerebrales.
First or Olfactory nerve.	N. Olfactorius.
Second or Optic nerve.	N. Opticus.
Third or Oculo-motor nerve.	N. Oculo-motorius.
Fourth or Trochlear nerve.	N. Trochlearis vel Patheticus.
Fifth or Trigeminal nerve.	N. Trigeminus.
Superior maxillary nerve.	N. Maxillaris.
Inferior ,, ,,	N. Mandibularis.
Sixth or Abducent nerve.	N. Abducens.
Seventh or Facial nerve.	N. Facialis.
Eighth or Auditory nerve.	N. Acusticus.
Ninth or Glosso-pharyngeal nerve.	N. Glosso-pharyngeus.
Jugular ganglion of ,,	Ganglion superius.
Petrous ganglion of ,,	,, petrosum.
Jacobson's nerve.	N. Tympanicus.
Tenth or Pneumogastric nerve.	N. Vagus.
Ganglion of Root of ,,	Ganglion jugulare.
Ganglion of Trunk of ,,	Ganglion nodosum.
Arnold's nerve.	N. Auricularis.
Eleventh or Spinal Accessory nerve.	N. Accessorius.
Twelfth or Hypoglossal nerve.	N. Hypoglossus.
Descendens cervicis (hypoglossi).	N. cervicalis descendens.
Cervical Plexus.	Plexus Cervicalis.
Small occipital nerve.	N. occipitalis minor.
Great auricular nerve.	N. auricularis magnus.
Superficial or Transverse cervical nerve.	N. cutaneus colli.
First cervical nerve.	N. suboccipitalis.
Great occipital nerve.	N. occipitalis major.
Third or Least occipital nerve.	N. ,, minimus.
Phrenic nerve.	N. phrenicus.

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ENGLISH.	LATIN.
Brachial Plexus.	**Plexus Brachialis.**
Nerve to the Rhomboid Muscles.	N. dorsalis scapulæ.
Long thoracic nerve, or External respiratory nerve of Bell.	N. thoracalis longus.
Anterior thoracic nerves.	N. thoracales anteriores.
Median nerve.	N. mediānus.
Ulnar ,,	N. ulnaris.
Circumflex nerve.	N. axillaris.
Long subscapular nerve.	N. thoraco-dorsalis.
Twelfth thoracic ,,	N. subcostalis.
Lumbar Plexus.	**Plexus Lumbalis.**
Genito-crural nerve.	N. genito-femoralis.
Crural branch of ,,	N. lumbo-inguinalis.
Genital branch of ,,	N. spermaticus externus.
External cutaneous nerve.	N. cutaneus femoris lateralis.
Obturator nerve.	N. obturatorius.
Anterior crural nerve.	N. femoralis.
Internal or long saphenous nerve.	N. saphēnus.
Sacral Plexus.	**Plexus Sacralis.**
Small sciatic nerve.	N. cutaneus femoris posterior.
Great ,, ,,	N. ischiadicus.
External popliteal, or Peroneal, nerve.	N. peronæus communis.
Lateral cutaneous branch of peroneal nerve.	N. cutaneus suræ lateralis.
Fibular communicating nerve.	N. anastomoticus peronæus.
Tibial ,, ,,	N. communicans tibialis.
Musculo-cutaneous nerve.	N. peronæus superficialis.
Anterior tibial nerve.	N. ,, profundus.
Internal popliteal, or Tibial, nerve.	N. tibialis.
External or short saphenous nerve.	N. cutaneus suræ medialis vel N. suralis.
Internal plantar nerve.	N. plantaris medialis.
External ,, ,,	N. plantaris lateralis.
Deep division of plantar nerve.	Ramus profundus.
Pudic nerve.	N. pudendus.

SPLANCHNOLOGY.

(The Visceral System).

Digestive System.

Mouth.	Cavum oris.
Lips.	Labia oris.
Cheeks.	Buccæ.

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ENGLISH.	LATIN.
Gums.	Gingīvæ.
Hard palate.	Palātum durum.
Soft ,,	,, molle vel Velum pendulum palāti.
Anterior pillar of the fauces.	Arcus glosso-palatīnus.
Posterior ,, ,, ,,	,, pharyngo-palatīnus.
Tongue.	Lingua.
Dorsum of the tongue.	Dorsum linguæ.
Inferior surface of the tongue.	Facies inferior.
Parotid gland.	Glandula parōtica.
Parotid, or Stensen's, duct.	Ductus parōticus.
Glandula socia parotidis.	Glandula parōtica accessoria.
Wharton's duct.	Ductus submaxillaris.
Pharynx.	Pharynx.
Tonsils.	Amygdalæ, vel Tonsillæ palatīnæ.
Crypts of the tonsil.	Fossulæ tonsillares.
Pharyngeal tonsil.	Tonsilla pharyngea.
Fossa of Rosenmüller.	Recessus pharyngeus.
Orifice of the Eustachian tube.	Ostium pharyngeum tubæ auditoriæ.
Eustachian cushion.	Torus tubæ auditoriæ.
Gullet (Œsophagus).	Gula.
Stomach.	**Ventriculus.**
Fundus (Cardiac end).	Fundus ventriculi.
Œsophageal orifice.	Cardia.
Pyloric orifice	Pylorus.
Plicæ villosæ.	Plicæ gastricæ.
Small Intestine.	**Intestinum Tenue.**
Valvulæ conniventes.	Plicæ circulares.
Glands of Brunner.	Glandulæ duodenales.
Crypts of Lieberkühn.	Glandulæ intestinales.
Solitary glands.	Noduli lymphatici solitarii.
Agminated glands, or Peyer's patches.	,, ,, aggregati.
Large Intestine.	**Intestinum Crassum.**
Ileo-colic, or ileo-cæcal, valve.	Valvula coli.
Upper segment of ,, ,,	Labium superius.
Lower segment of ,, ,,	,, inferius.
Retinacula of ,, ,,	Frenula valvulæ coli.
Vermiform appendix.	Processus vermiformis.
Ascending colon.	Colon vel Colum dextrum.
Hepatic flexure.	Flexūra dextra coli.
Transverse colon.	Colon transversum vel medium.

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ENGLISH.	LATIN.
Splenic flexure.	Flexūra sinistra coli.
Descending colon.	Colon sinistrum.
Iliac colon.	Colon iliăcum.
Pelvic colon	Colon pelvĭcum.
Sacculi of colon.	Haustra coli.
Crescentic folds between the sacculi.	Plicæ semilunares coli.
Rectum.	Intestinum rectum.
Rectal valves, or Valves of Houston.	Plicæ transversales recti.
Anal canal.	Pars analis intestini recti.
Columns of Morgagni.	Columnæ canalis analis.
Liver.	**Hepar.**
Suprarenal impression.	Impressio suprarenalis.
Gastric ,,	,, gastrica.
Colic ,,	,, colica.
Renal ,,	,, renalis.
Duodenal ,,	,, duodenalis.
Omental tuberosity.	Tuber omentale.
Quadrate lobe.	Lobus quadratus.
Caudate lobe.	Lobus vel Processus caudatus.
Fossa of the inferior vena cava.	Fossa venæ cavæ inferioris.
,, (fissure) of the ductus venosus.	,, ductūs venosi.
Umbilical fissure.	,, venæ umbilicalis.
Portal, or Transverse, fissure.	Porta hepătis.
Fossa of the gall-bladder.	Fossa vesĭcæ fellĕæ.
Round ligament.	Ligamentum teres hepătis vel Ligamentum venosum.
Hepatic duct.	Ductus hepaticus.
Capsule of Glisson.	Capsula fibrosa.
Gall-bladder.	**Vesica Felliĕa.**
Cystic duct.	Ductus cysticus.
Common bile-duct.	,, communis cholēdochus.
Spleen.	**Lien.**
Diaphragmatic surface.	Facies diaphragmatica.
Gastric surface.	,, gastrica.
Renal ,,	,, renalis.
Basal ,,	,, basalis.
Kidneys.	**Rēnes** (singular, **Rēn**).
Muscular surface.	Facies muscularis.
Visceral ,,	,, visceralis.
Pyramids of Malpighi.	Pyramides renales.
Columnæ Bertini.	Columnæ renales.

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ENGLISH.	LATIN.
Medullary rays.	Pars radiata.
Labyrinth.	,, convolūta.
Malpighian corpuscles.	Corpuscula renis.
Uriniferous tubules.	Tubuli renales.
Renal arteries.	Arteriæ renis.
Renal veins.	Venæ renis.
Urinary Bladder.	**Vesica Urinaria.**
Base of bladder.	Fundus vesīcæ.
Summit, or Apex, of bladder.	Vertex vesīcæ.
Body of bladder.	Corpus vesīcæ.
Urethral orifice of bladder.	Orificium internum urethræ.
Fibrous cord of the urachus.	Ligamentum umbilicale medium.
Peritoneal coat.	Tunica serosa.
External muscular coat.	Stratum musculare externum.
Middle ,, ,,	,, ,, medium.
Internal ,, ,,	,, ,, internum.
Sphincter muscle.	Annulus urethralis.
Submucous coat.	Tela submucosa.
Mucous coat.	Tunica mucosa.
Male Reproductive Organs. Testicles.	**Orgăna Genitalia Virilia. Testes.**
Tunica vaginalis testis.	Lamina visceralis.
Tunica ,, scroti.	,, parietalis.
Globus major of Epididymis.	Caput epididymis.
Globus minor ,,	Cauda ,,
Organ of Giraldès.	Paradidymis.
Digital fossa.	Sinus epididymis.
Coni vasculosi.	Lobuli epididymis.
Vas deferens.	Ductus testis.
Spermatic cord.	Funiculus spermaticus.
Penis.	**Penis.**
Upper surface of penis.	Dorsum penis.
Under ,, ,,	Facies urethralis.
Body of penis.	Corpus penis.
Prepuce.	Præputium.
Glands of Tyson.	Glandulæ præputiales.
Corpora cavernosa.	Corpora cavernosa penis.
Corpus spongiosum.	Corpus cavernosum urethræ.
Prostate Gland.	**Glandula Prostatica vel Prostadica.**
Base of prostate gland.	Basis prostadis.
Apex of ,, ,,	Apex prostadis.

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ENGLISH.	LATIN.
Male Urethra.	**Urethra Virilis.**
Prostatic part.	Pars prostatĭca vel prostadĭca.
Membranous part.	,, membranacea.
Spongy part.	,, cavernosa.
Meatus urinarius.	Orificium externum urethræ.
Glands of Cowper.	Glandulæ bulbo-urethrales.
Glands of Littré.	,, urethrales.
Female Reproductive Organs.	**Orgăna Genitalia Muliebria vel Femĭnĕa.**
Ovary.	Ovarium.
Upper, or Tubal, pole of ovary.	Extremitas tubalis.
Lower, or Uterine, pole of ovary.	,, uterina.
Anterior border of ovary.	Margo mesovarii.
Peritoneal fold of ovary.	Mesovarium.
Ligament of ovary.	Ligamentum proprium ovarii.
Peritoneal fossa of ovary.	Fossa ovarii.
Graafian follicles.	Folliculi vesiculosi oöpherii.
Discus proligerus.	Cumŭlus oöpherii.
Fallopian Tube.	**Tuba Uterina.**
Duct of Gartner.	Ductus epoöpherii longitudinalis.
Hydatids of Morgagni.	Appendices vesiculosi.
Uterus.	**Uterus.**
Anterior surface.	Facies vesicalis.
Posterior ,,	,, intestinalis.
Cavity of the cervix.	Canalis cervicis uteri.
Plicæ palmatæ.	Arbor vitæ uterina.
Broad ligament.	Ligamentum latum uteri.
Round ,,	,, teres ,,
Peritoneal coat.	Tunica serosa.
Vagina.	**Vagina.**
Lower part of anterior column.	Carina urethralis.
Vulva, or Pudendum.	**Pudendum muliebre vel femĭnĕum.**
Fourchette.	Frenulum labiorum pudendi.
Female urethra.	Urethra muliebris vel femĭnĕa.
Meatus urinarius.	Orificium externum urethræ.
Mammary Gland.	**Mamma.**
Glands of Montgomery.	Glandulæ areolāres.
Galactophorous ducts.	Ductûs lactiferi.
Ampulla of galactophorous duct.	Sinus lactiferus.

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ENGLISH.	LATIN.
Larynx.	**Larynx.**
Thyroid cartilage.	Cartilago thyroidea.
Oblique line.	Linea obliqua.
Cricoid cartilage.	Cartilago cricoidea.
Arytenoid cartilages.	Cartilagines arytænoideæ.
Cartilages of Santorini.	,, corniculatæ.
Cartilages of Wrisberg.	,, cuneatæ.
Epiglottis.	Epiglottis.
Tubercle, or Cushion, of epiglottis.	Pulvinar epiglottideum.
Superior aperture of the larynx.	Aditus laryngis.
Cavity of the larynx.	Cavum laryngis.
Superior thyro-arytenoid ligament.	Ligamentum ventriculosum.
Inferior thyro-arytenoid ligament.	,, vocale.
False vocal cords.	Plicæ ventriculosæ.
True ,, ,,	,, vocales.
False glottis.	Glottis spuria.
True ,,	Glottis vera, vel Rima glottidis.
Vocal glottis.	Pars intermembranacea.
Respiratory glottis.	,, intercartilaginea.
Ventricle of the larynx.	Ventriculus laryngis.
Saccule ,, ,,	Appendix ventriculi.

Organs of Sense.

Eye.	**Oculus vel Orgănum visûs.**
Eyeball.	Globus oculi.
Capsule of Tenon.	Fascia bulbi.
Sclerotic coat.	Sclera.
Canal of Schlemm.	Sinus venosus scleræ.
Membrane of Bowman.	Lamina elastica anterior.
Membrane of Descemet, or of Demours.	,, ,, posterior.
Choroid coat.	Tunica chorioidea.
Membrane of Bruch.	Lamina basalis.
Ciliary body.	Corpus ciliare.
Zonula of Zinn.	Zonula ciliaris.
Valve of Hasner.	Plica lacrimalis.

Ear.	**Auris Orgănum Auditûs.**
External Ear (Auricle).	**Auris Externa (Auricula).**
Upper portion of concha, above crus helicis.	Cymba conchæ.
Lower portion of concha, below crus helicis.	Cavum conchæ.
Tubercle of Darwin.	Tuberculum auriculæ.

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ENGLISH.	LATIN.
Fossa of the helix.	Scapha.
Fossa of the antihelix.	Fossa triangularis.
Eminence on cranial aspect of concha.	Eminentia conchæ.
Hairs of tragus and antitragus.	Barba hircīna.
External auditory meatus.	Meatus acusticus externus.
Sweat-glands of auditory meatus.	Glandulæ ceruminosæ.
Middle Ear.	**Auris Media.**
Tympanic cavity.	Cavum tympani.
Outer wall of ,,	Paries membranacea.
Inner ,, ,,	,, labyrinthica.
Anterior wall ,,	,, carotica.
Posterior ,, ,,	,, mastoidea.
Roof ,, ,,	,, tegmentalis.
Floor ,, ,,	,, jugularis.
Tympanic Membrane.	**Membrāna Tympani.**
Shrapnell's membrane.	Membrāna vel Pars flaccida.
External layer of tympanic membrane.	Stratum cutaneum.
Middle layer of tympanic membrane.	Membrāna propria (Stratum radiatum et stratum circulare).
Internal layer of tympanic membrane.	Stratum mucosum.
Fenestra ovalis.	Fenestra vestibuli.
Fenestra rotunda.	,, cochleæ.
Secondary membrane of the tympanum.	Membrāna tympani secundaria.
Mastoid antrum.	Antrum mastoideum vel tympanicum.
Eustachian tube.	Tuba auditoria.
Tympanic orifice of tube.	Ostium tympanicum.
Pharyngeal ,, ,,	,, pharyngeum.
Tympanic Ossicles.	**Ossicula Auditûs.**
Malleus.	**Malleus.**
Handle.	Manubrium.
Long process.	Processus longus.
Short ,,	,, brevis.
Incus.	**Incus.**
Long process.	Crus longum.
Short ,,	,, breve.

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ENGLISH.	LATIN.
Stapes.	**Stapes.**
Anterior crus.	Crus anterius.
Posterior ,,	,, posterius.
Foot-plate.	Basis.
Internal Ear.	**Auris Interna.**
Osseous Labyrinth.	**Labyrinthus Osseus.**
Vestibule.	**Vestibulum.**
Fovea spherica.	Recessus sphericus.
,, elliptica.	,, ellipticus.
Cochlea.	**Cochlea.**
Base of cochlea.	Basis.
Apex ,,	Cupola.
Modiolus.	Columella.
Spiral canal of the modiolus.	Canalis spiralis modioli.
Internal auditory meatus.	Meatus acusticus internus.
Membranous Labyrinth.	**Labyrinthus Membranaceus.**
Canal of Hensen.	Ductus reuniens.
Membranous cochlea.	,, cochlearis vel Scala media.
Membrane of Reissner.	Membrana vestibularis.
Basilar membrane.	,, basilaris.
Nose.	**Nasus.**
Cartilage of the septum.	Cartilago septi nasi.
Vomerine cartilage.	Cartilago vomero-nasalis Jacobsoni.
Upper lateral nasal cartilage.	Cartilago nasi lateralis superior.
Lower lateral nasal cartilage.	,, ,, ,, inferior vel Cartilago apertūræ nasi.
Outer plate of nasal cartilage.	Crus laterale.
Inner plate of ,, ,,	Crus mediale.
Superior meatus.	Meatus nasi superior.
Middle ,,	,, ,, medius.
Inferior ,,	,, ,, inferior.
Glands of Bowman.	Glandulæ olfactoriæ.

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GLOSSARY

Abdōmen, probably from *abdo,* I hide or conceal; perhaps a corruption of **adipōmen,** from *adeps,* the soft fat of animals.
Aberrant, wandering from the normal source.
Acervŭlus, a little heap.
Acetabulum, a vessel for holding vinegar; a juggler's cup.
Acinus, any juicy berry with stones, *e.g.,* the grape; the kernel in the berry.
Acrocephalus, pointed or conical head.
Acromion, the point or summit of the shoulder.
Acusticus, -a, -um, pertaining to sound, or to the sense of hearing.
Adamantoblast, enamel-germ.
Aditus, an approach or access.
Adnāta, born to.
Adrenal, near to, or pertaining to, the kidney.
Advehens, carrying to.
Afferent, carrying to.
Agger, a mound or rampart.
Agminated, in groups.
Ala, a wing.
Albicans, white.
Albuginea, whitish.
Allantois, sausage-like.
Alveolus, a little trough.
Alveus, a trough.
Amacrine, without a long fibre.
Ambiguus, dark, obscure.
Ammōnis, cornu, horn of Ammon, who was represented as having the head of a ram.
Amphiarthrosis, literally, articulation on both sides.
Ampulla, a flask.
Amygdala, an almond.
Anastomosis, literally, an outlet; the communication of branches of vessels with one another.
Anconēus, pertaining to the elbow.
Ankylosis, bony union between two bones which are normally separate.
Annulus, a little ring.
Ansa, a handle, haft, or brace.
Anserinus, pertaining to a goose.
Antecubital (Anticubital), before the elbow.
Anticus, in front, anterior.
Antinion, facing the inion.
Antrum, a cave or cavity.
Anus, a ring.
Aorta, literally, the lower end of the trachea; a carrier.
Aponeurosis, an expansion from a tendon.
Apophysis ('grow from'), a process or swelling on a bone.
Arachnoid, like a spider's web.
Arcuatus, curved.
Areola, a small open place.
Artery, literally, the trachea; a bloodvessel which carries the blood from the heart.

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Arthrodia, from a Greek word meaning 'a joint'; gliding is implied.
Arytenoid, pitcher-like.
Aspera, rough.
Asterion, a star.
Astragalus, the ankle-bone; a die (pl. dice).
Atlas, a support.
Atresia, imperforation.
Atrium, the hall in a Roman house.
Attollens, raising up, elevating.
Attrahens, drawing to or towards.
Auditory, pertaining to the organ, or sense, of hearing.
Auricle, the external ear.
Azygos, without a yoke, single.

Bacillary, pertaining to a small staff or rod.
Balănus, an acorn.
Barba, a beard.
Basilar, belonging to the base.
Basilic, royal, important.
Basion, base.
Biceps, having two heads.
Bicornis, two-horned.
Biventer, having two bellies.
Brachium, the arm.
Brachycephalic, short-headed.
Bregma, from a Greek verb meaning 'to moisten.'
Bronchial, pertaining to the windpipe.
Bronchiole, a little bronchus.
Bronchus, literally, a draught; the windpipe.
Bubonocele, a tumour in the groin.
Buccinator, a trumpeter.
Bulla, a knob.
Bursa, a sac containing fluid.

Cacūmen, tip, peak, or end.
Cæcum, blind.
Cæruleus, dark blue.
Calamus, a reed-pen.
Calcaneum, the heel.
Calcar, a spur.
Calcination, reduction to a powder (or lime) by heat.
Calcis, of the heel.
Calix, a cup or goblet.
Callosum, hard, thick.
Calvaria (*calva*, the bald scalp), the upper part of the skull.
Cancellated, lattice-formed, reticulated.
Caninus, canine.
Canthus, the corner of the eye.
Capillary, pertaining to the hair; a vessel of hair-like minuteness.
Capitellum, a small head.
Cardia, the opening of the stomach; the heart.
Cardiac, pertaining to the heart.
Cardinal, principal or chief.
Carina, a keel.
Carneæ, pertaining to flesh.
Carōtid, stupefying; or perhaps from two Greek words meaning 'head' and 'ear.'
Carpus, the wrist.
Caruncula, a little piece of flesh.
Cauda, a tail.
Caudal, pertaining to a tail.
Caudate, pertaining to a tail.
Cavernous, full of hollows or cavities.
Centimetre (cm.), $\frac{2}{5}$ of an English inch.
Cephalic, pertaining to the head.
Cerăto, horny.
Ceruminous, pertaining to wax.
Chiasma, two lines placed like an X.
Choāna, a funnel.
Choledŏchus, bile-receiving.
Chondral, pertaining to cartilage.
Choroid (Chorioid), like skin.
Cinereus, ash-coloured.
Cingulum, a small girdle.
Circumflexus, bent around.
Cisterna, a cistern or reservoir.

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Claustrum, a bolt, barrier, or inclosure.
Clava, a club.
Clavicle, from *clavis*, a key.
Cleido-, pertaining to the clavicle.
Clinoid, like a bed (bed-post).
Clitoris, from a Greek verb meaning 'I shut up' or 'enclose.'
Clivus, a slope.
Cloāca, a sewer or drain.
Coccyx, a cuckoo.
Cochlea, a snail.
Cochleariformis, spoon-like.
Cœliac, pertaining to the belly.
Collicŭlus, a little hill.
Colon, the great gut.
Comes, a companion.
Complexus, literally, folded together; encompassing.
Conarium, a small cone.
Concatenatæ, chained together.
Concha, a shell.
Condyle ('knuckle'), a small round prominence covered by cartilage.
Conjunctiva, connecting.
Conniventes, winking or blinking.
Conoid, cone-like.
Convolūta, rolled together.
Coracoid, like a crow or raven.
Cordiform, heart-shaped.
Cornea, horny.
Corniculum, a little horn.
Corōnal, literally, pertaining to a crown; transverse.
Coronary, encircling.
Coronoid, like a crooked beak.
Corrugator, a wrinkler.
Cortex, the bark or outer covering.
Costal, pertaining to a rib.
Cotyloid, cup-like.
Coxa, the hip.
Cranium, the skull.
Crassum, thick, dense, or bulky.
Cremaster, a suspender.
Cretin, a simple-minded person.
Cribriform, sieve-like.
Cribrosa, perforated with sieve-like pores.
Cricoid, like a ring.
Crucial, pertaining to, or shaped like, a cross.
Crural, pertaining to the leg.
Cryptorchismus, concealment of the testis.
Cryptozygous, hidden arches.
Cubitum, the elbow.
Cucullaris, pertaining to a cowl or hood.
Culmen, the top or summit.
Cuneate, wedge-shaped.
Cuneus, a wedge.
Cupola, a dome.
Cymba, a boat or skiff.
Cystic, pertaining to the gall-bladder.
Cytoplasm, formative yolk.

Dacryon, a tear.
Dartos, skinned or flayed.
Deciduous, falling away.
Deferens, carrying away.
Detrūsor, from *detrūdo*, I drive away.
Deutoplasm, nutritive yolk.
Dia-, through or between.
Diaphragm, a partition.
Diaphysis ('grow between'), the shaft of a bone, or the part which grows between the epiphyses.
Diarthrosis, an 'apart' joint (without intervening substance).
Diencephalon, the 'tween-brain or inter-brain.
Digastric, having two bellies.
Diploë, a doubling.
Diverticulum, from *diverto*, 'I separate,' or 'part,' or 'go a different way.'
Dolichocephalic, long-headed.
Dorsal, pertaining to the back aspect.
Dorsum, the back.
Duodēnum, twelve.

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Ebur, -ŏris, ivory.
Eburnea, pertaining to ivory.
Ectopia, a displacement.
Efferent, carrying out.
Emboliformis, beak-shaped or wedge-shaped.
Emissary, sent out.
Emulgent, milking, straining out.
Encephalon, the contents of the head or skull.
Endocardium, 'within the heart'; the lining membrane of the cardiac chambers.
Endognathion, literally, inner jaw.
Endosteum, 'within a bone'; the medullary membrane.
Ensiform, sword-like.
Entomion, a notch.
Ependyma, from a Greek word meaning 'clothing.'
Ephippium, a saddle.
Epi-, upon or over.
Epicardium, upon the heart.
Epididymis, upon the testicle.
Epiotic, upon or over the ear.
Epiphysis ('grow upon'); a process of a bone which has a secondary centre of ossification.
Epiploön, from a Greek verb meaning 'I sail upon.'
Epipteric, upon a wing.
Epoöphoron, upon the egg-bearing organ.
Equina, pertaining to a horse.
Erythrŏblast, red germ.
Ethmoid, sieve-like.
Exognathion, literally, outer jaw.
Exomphalos, out of the navel.

Facet (French, *facette*, a little face), a small plane articular surface.
Falciform, sickle-like.
Falx, a sickle.
Fascia, a band.
Fasciculus, a small bundle.
Fauces, the throat.
Fel, fellis, the gall-bladder.
Fellea, pertaining to the gall-bladder.
Femur, the thigh.
Fenestra, an opening, a window.
Ferruginea, pertaining to iron-rust.
Fibula, a buckle, clasp, or brace
Filum, a thread.
Fimbria, a fringe.
Fimbriātum, fringed.
Fissure, a cleft or slit.
Fistula, a pipe or tube.
Flocculus, a little lock of wool.
Follicle, a small bag or sac.
Fontanelle, a small spring.
Foramen, an aperture or a hole.
Forceps, a claw of a beetle.
Fornicatus, pertaining to an arch.
Fornix, an arch or a vault.
Fossa, a ditch or trench.
Fourchette, a fork.
Fovea, a small pit.
Foveola, a small pit.
Frenum, a bridle.
Frenulum, a small bridle.
Frontal, pertaining to the forehead.
Fundiform, sling-like.
Funicular, pertaining to a cord.
Funiculus, a slender rope, a cord.
Furcalis, pertaining to a two-pronged fork.
Furcula, a small two-pronged fork.
Fusca, dark or dusky.

Galactophorous, milk-carrying.
Galĕa, a helmet.
Gallinaginis, of a woodcock.
Gallus, a cock.
Ganglion, a swelling or excrescence.
Gastric, pertaining to the stomach.
Gastrocnemius, the belly of the leg.
Gemellus, paired or double.
Geminus, double or twofold
Geniculate, knee-like.
Genio-, pertaining to the chin.
Genu, the knee.

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Ginglymus, a hinge.
Glabella, without hair ; smooth.
Gladiolus, a small sword.
Glenoid, like a shallow socket.
Globosus, round or spherical.
Globus, a globe or sphere.
Glomerulus, a small ball of thread.
Glosso-, pertaining to the tongue.
Glottis, the mouthpiece of a flute.
Gluteal, pertaining to the buttock.
Gnathic, pertaining to the jaw.
Gnathion, the jaw.
Gomphosis, a bolting together.
Gonion, an angle.
Gracilis, slender.
Grisea, grey.
Gubernaculum, a rudder.
Gula, the gullet.
Gustatory, pertaining to taste.
Guttural, pertaining to the throat.
Gyrus, a circle ; a crook.

Habenula, a small rein.
Haliux, the great toe.
Ham, see p. 415 (footnote).
Hamular, hook-shaped.
Harmonia, a fitting together.
Haustrum, a machine for drawing water.
Helicine, spiral.
Helicotrēma, hole of a spiral.
Helix, a coil or spiral.
Hemorrhoidal, pertaining to hemorrhoids or piles.
Hepar, the liver.
Hepatic, pertaining to the liver.
Hernia, a sprout ; a rupture.
Hiatus, a gap.
Hilum, a little thing, a trifle.
Hippocampus, a seahorse.
Hircina, pertaining to a goat.
Homodynamic, having the same force or value.
Homogenesis, one and the same generation.
Homologous, agreeing in position or structure.
Humerus, the upper part of the arm ; the shoulder.
Hyaline, glassy.
Hyaloid, like glass.
Hydatid, a watery vesicle.
Hydrocele, a watery tumour.
Hymen, a thin skin or membrane.
Hyoid, like the Greek letter upsilon.
Hypo-, beneath or under.
Hypophysis, ' grow beneath.'
Hypothenar, beneath the palm of the hand.

Ileum, implying twists or coils.
Ilium, the flank.
Ima, lowest.
Impar, dissimilar (in number), unequal.
Incisivus, cutting into.
Infundibulum, a funnel.
Infundibuliform, funnel-shaped.
Inguinal, pertaining to the groin.
Inion, literally, the occiput.
Innominatum, unnamed.
Insula, an island.
Intercalary, inserted.
Internodium, between two joints.
Interpositum, placed between.
Interstitial, belonging to interstices or small intervals separating the minute parts of bodies.
Iris, the rainbow.
Ischiatic, pertaining to the hip.
Ischium, the hip.
Iter, a passage or road.

Jejunum, empty.
Jugal, yolking.
Jugular, pertaining to the throat.
Jugum, a yolk.

Labrum, a basin.
Lachrymal, pertaining to tears.
Laciniosum, full of folds, indented, jagged.
Lacteal, pertaining to milk.
Lactiferous, milk-carrying.

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Lacuna, a hollow or cavity.
Lacunar, pertaining to a hollow or gap.
Lamella, a small plate.
Lamina, a plate.
Lateral, external.
Latissimus, broadest.
Latum, broad.
Lemniscus, a ribbon.
Leptorhine, having small narrow nostrils.
Levator, a lifter or raiser.
Lien, the spleen.
Liēno-, pertaining to the spleen.
Ligament, a band.
Ligula, a little tongue.
Limbous, pertaining to a border.
Limbus, a border.
Limen, a threshold.
Linea, a line.
Lingual, pertaining to the tongue.
Lingula, a little tongue.
Longissimus, longest.
Lumbar, pertaining to the loin.
Lumbricalis, pertaining to an earth-worm.
Lunar, pertaining to the moon.
Lunula, a little moon.
Luteum, muddy, like clay.
Lymphatic, from *lympha,* pure or spring water ; lymph.
Lyra, a lyre.

Macula, a spot.
Malar, pertaining to the cheek.
Malleolus, a small hammer or mallet.
Malleus, a hammer or mallet.
Mamma, a breast or pap.
Mammilla, a little breast or pap.
Mandible, the chewing bone.
Manubrium, a handle or hilt.
Massēter, the chewing muscle.
Mastoid, breast- or pap-like (nipple-like).
Maxilla, jaw.
Meatus (pl. **meatûs**), a passage or canal.
Mediastinum, standing in the middle.
Medulla, marrow.
Megacephalic, having a large head.
Megaseme, great index.
Meninges, membranes.
Meniscus, a crescent.
Mental, pertaining to the chin.
Meso-, middle.
Mesaticephalic, pertaining to an intermediate head.
Mesencephalon, the mid-brain.
Mesentery, middle intestine.
Mesial, internal.
Mesocephalic, pertaining to an intermediate head.
Mesogastrium, middle belly.
Mesognathion, middle jaw.
Meso-nephros, mid-kidney.
Mesorhine, pertaining to an intermediate nose.
Mesosalpinx, middle of trumpet or tube.
Mesoseme, intermediate index.
Meta-, after or beyond.
Meta-nephros, hind-kidney.
Metencephalon, the after-brain.
Metopic, pertaining to the forehead.
Metopism, persistence of the metopic or frontal suture.
Microcephalic, pertaining to a small head.
Microseme, small index.
Millimetre (mm.), slightly less than $\frac{1}{25}$ of an English inch.
Minimæ, least, smallest.
Mitral, resembling an Asiatic head-dress.
Modiolus, the nave of a wheel.
Molar, pertaining to a mill, or to grinding.
Montānum, pertaining to a mountain.
Monticulus, a small mountain.
Morbus, a disease.
Muliebris, pertaining to a woman, feminine.

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Multifidus, many cleft ; divided into many parts.
Myelencephalon, marrow-brain.
Myeloplaxes, marrow-plates.
Myentericus, pertaining to the muscular tissue of the bowel.
Mylo-, pertaining to a mill.
Myocardium, the muscular tissue of the heart.
Myoides, muscle-like.
Myrtiform, like a myrtle-berry.

Naris (pl. **nares**), a nostril.
Nasal, pertaining to the nose.
Natal, pertaining to the buttock.
Natis (pl. **nates**), the buttock.
Navicular, pertaining to a boat.
Nephros, a kidney.
Neural, pertaining to a nerve.
Neuroglia, ' nerve and glue.'
Nictitans, winking.
Norma, a rule or measure, (aspect).
Notochord, string or cord of the back.
Nucha, the nape of the neck.
Nucleus, a kernel.
Nymphæ, demi-goddesses, or inferior deities, of the fountains.

Obelion, a horizontal line (perhaps a little spit).
Obex, a bolt.
Obturator, a stopper-up.
Occipital, against the head.
Odontoblast, a tooth-germ.
Odontoid, tooth-like.
Odoriferæ, carrying odours.
Œsophagus, food-carrier.
Olecranon, head of the elbow.
Olfactory, pertaining to smell.
Olivary, pertaining to an olive.
Omentum, a caul or net ; the fat-skin.
Omo-, pertaining to the shoulder.
Omphalo-, pertaining to the navel.
Operculum, a covering.
Ophryon, the eyebrow.
Ophthalmic, pertaining to the eye.
Opisthion, hinder or rear.
Opisthotic, behind the ear.
Optic, pertaining to sight.
Ora, a border or margin.
Orthognathous, pertaining to a straight or upright jaw.
Os, oris, a mouth.
Os, ossis, a bone.
Osteoblast, bone-germ.
Osteoclast, bone-destroyer.
Osteogenetic, bone-begetting.
Ostium, a door, entrance, or exit.
Otic, pertaining to the ear.
Otoconia, ear-dust.
Otoliths, ear-stones.
Ovary, egg-former.
Oxyntic, producing acid.

Palātum, the palate.
Pallium, a covering.
Palmar, pertaining to the palm.
Palmatæ, marked with the palm.
Palpebra, an eyelid.
Pampiniform, tendril-like.
Pancreas, literally, all flesh.
Para-, near, by the side of.
Paradidymis, near the testis.
Parametrium, near the womb.
Parietal, pertaining to a wall.
Paroöphoron, near the egg-bearing organ.
Parōtid, near the ear.
Patella, a small dish ; a plate.
Patheticus, affecting.
Pecten, the os pubis.
Pectinātus, pertaining to a comb
Pectiniform, comb-like.
Pectineal or **Pectinēus,** pubic.
Pectoralis, pertaining to the breast.
Pelvis, a basin.
Penis, a tail.
Peri-, around, about, or near.
Pericardium, around the heart.
Perineum, from a Greek verb meaning ' I dwell, or am situated, around.'
Periosteum, around a bone.

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Periotic, around the ear.
Peritoneum, from a Greek verb meaning 'I stretch around.'
Peronēal or **Peronēus,** pertaining to a buckle, clasp, or brace.
Petrous, rocky.
Phalanx, a rank of soldiers.
Pharynx, the throat.
Phenozygous, having visible arches.
Philtrum, a love charm or potion.
Phrenic, pertaining to the diaphragm.
Pinēal, belonging to, or like, a pine-nut or pine-cone.
Pinna, a kind of shell-fish; a feather or wing.
Pisiform, like a pea.
Pituitary, pertaining to phlegm or mucus.
Placenta, a flat cake.
Plagiocephalous, pertaining to an oblique or twisted head.
Planta, the sole of the foot.
Plantar, pertaining to the sole of the foot.
Platycnēmism, broadness of leg.
Platyrhine, pertaining to a broad nose.
Platysma, a broad sheet.
Pleura, a side, or a rib.
Plexus, a twining or network.
Plica, a fold.
Pneumogastric, pertaining to the breathing organs and stomach.
Pocularis, pertaining to a cup.
Pollex, the thumb.
Pons, a bridge.
Poplitēal or **Poplitēus,** pertaining to the ham.
Porta, a gate.
Portal, pertaining to a gate.
Postaxial, distal or caudal.
Posticus, posterior.
Præputium, the prepuce.
Preaxial, proximal or cephalic.
Proctodæum, the threshold of the anus.
Prognathous, pertaining to a projecting lower jaw.
Proligerus, bearing offspring; germinating.
Pro-nephros, fore-kidney.
Pro-otic, before the ear.
Prosencephalon, the fore-brain.
Prostate, standing before; or, more probably, pertaining to a porch or vestibule.
Psalterium, a psaltery or instrument of the lute kind.
Psoas, the loin.
Pterion, a wing.
Pterotic, pertaining to a wing.
Pterygoid, wing-like.
Pubes, the hair which appears on the external genital organs at the age of puberty.
Pubic, pertaining to the os pubis.
Pudendal, pertaining to the pudendum.
Pudendum, 'of which one ought to be ashamed.'
Pudic, modest or chaste.
Pulmo, a lung.
Pulmonary, belonging to the lungs.
Pulvinar, a couch or cushion.
Putāmen, that which is pruned off; chippings.
Pylōrus, literally, a gate-keeper.
Pyriformis, pear-shaped.

Quadrātus, square.
Quadriceps, having four heads.
Quadrigeminus, fourfold, four.

Racemose, pertaining to a cluster of grapes; full of clusters; clustering.
Radius, a staff or rod; the spoke of a wheel.
Ramus, a branch.
Ranine, pertaining to a frog.
Raphé, a seam.

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Receptaculum, a receptacle.
Rectus, straight.
Recurrent, running back.
Refractory, breaking up.
Ren, a kidney.
Renal, pertaining to a kidney.
Restiform, like a rope or cord.
Rete, a net.
Retina, from *rete*, a net.
Retrahens, drawing back.
Revehens, carrying back.
Rhinencephalon, the 'nose' or olfactory brain.
Rhinion, a nose.
Rhombencephalon, the rhomb-brain (hind-brain).
Rima, a cleft or chink.
Risorius, laughing.
Rostrum, a beak.
Rotula, a little wheel.
Rugæ, wrinkles.

Sacrum, sacred.
Sagittal, pertaining to an arrow ; antero-posterior.
Salpinx, a trumpet or tube.
Salvatella, saving, or making well.
Saphēnous, manifest.
Sartorius, pertaining to a tailor.
Scala, a ladder, flight of steps, or staircase.
Scalēnus, of unequal sides.
Scansorius, of, or for, climbing.
Scaphocephalous, pertaining to a head like a boat.
Scaphoid, like a boat.
Scapula, a spade ; probably from a Greek verb meaning 'I dig.'
Schindylesis, a splitting or cleavage.
Sciatic (identical with **Ischiatic**), pertaining to the hip.
Sclera, hard.
Sclerotic, hard.
Scrobiculus, a little ditch or trench.
Scrotum, a skin-bag or -pouch ; a hide.
Sebaceous, pertaining to tallow, suet, or grease.
Sella, a seat ; a saddle.
Seminalis, pertaining to semen.
Septum, a fence or barrier.
Serotinus, that comes or happens late.
Serrātus, saw-shaped.
Sesamoid, like sesamé (a kind of grain).
Sigmoid, like the Greek letter Σ (sigma).
Sinus, a cavity or hollow.
Smegma, a cleanser.
Solar, relating to the sun.
Soleus, a sole or sandal ; a sole-fish.
Sperma, seed or semen.
Spermatic, pertaining to semen.
Spermatoblast, a seminal bud.
Spermatozoa (plural), seminal animals.
Sphenoid, wedge-like.
Sphenotic, pertaining to the sphenoid bone and ear-capsule.
Sphincter, binding or closing tight.
Splanchnic, pertaining to viscera.
Splenium, a bandage or compress.
Splenius, pertaining to a bandage.
Squamous, scaly.
Stapedius, pertaining to a stirrup.
Stapes, a stirrup.
Stellātum, starry.
Stephanion, a crown or wreath.
Sternebra, a segment of the sternum.
Sternum, the breast or chest.
Stomata, mouths or pores.
Stomatodæum or **Stomodæum,** the threshold of the mouth.
Styloid, pen-like.
Subflava, somewhat yellow.
Sulcus, a furrow.
Sural, pertaining to the calf of the leg.
Sustentaculum, a prop or support.
Suture, a sewing together, a seam.

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Symphysis, growth together.
Syn-, with; together with, (union or harmony may be implied).
Synarthrosis, literally, a 'together with' (direct) joint.
Synchondrosis, 'with cartilage.'
Syndesmosis, 'with a band' or 'ligament.'
Synovia, resemblance to the white of an egg.

Tænia, a band or ribbon.
Talus, a die (pl. dice); the ankle-bone.
Tapētum, a carpet or coverlet.
Tarsus, a broad flat surface; the instep.
Tectorius, pertaining to a cover.
Tegmen, a covering.
Tegmentum, a covering.
Tela, a web.
Telencephalon, the end-brain.
Temporal, pertaining to time.
Tendon, from *tendo,* 'I stretch.'
Tentorium, a tent.
Tenuis, slender, small.
Teres, rounded.
Testis, a witness.
Thalamencephalon, the bed-chamber-brain, or inter-brain.
Thalamus, a bed-chamber, situated between two other rooms; a marriage-bed.
Theca, a cover, case, or sheath.
Thenar, pertaining to the palm.
Thorax, the breast or chest; a breast-plate.
Thymus, thyme.
Thyroid, like a shield.
Tibia, a pipe or flute; the shin-bone.
Tinca, a small fish, perhaps the tench.
Torcular, a wine-press (twisting is implied).
Torus, a protuberance.
Trabecula, a little beam.
Trachea ('rough'), the wind-pipe.
Trachēlo-, belonging to the neck.
Tragus, a goat.
Trapezium, a table; a four-sided figure, no two sides of which are parallel to one another.
Trefoil, having three leaves.
Triceps, having three heads.
Trigeminus, threefold, triple.
Trigonocephalus, a triangular head.
Trigōnum, a triangle; triangular.
Triquetrum, three-cornered; triangular.
Triticeă, wheaten.
Trochanter, from a Greek verb meaning 'I roll, turn, or revolve.'
Trochlea, the wheel of a pulley.
Trochlear, pulley-shaped.
Trochlearthrosis, a pulley-joint.
Trochoides, wheel-like.
Tuba, a trumpet.
Tubarius, pertaining to a trumpet.
Tubercle, a small swelling.
Tuberosity, an exaggerated tubercle.
Turbinate, whirled or coiled; like a top.
Turbo, a whirl or coil; a top.
Turcica, Turkish.
Tympanum, a drum.

Ulna, the elbow.
Umbilicus, the navel.
Umbo, a boss or knob.
Unciform, hook-like.
Uncinate, furnished with a hook.
Ungual, relating to a nail.
Unguis, a nail.
Unicornis, one-horned.
Urăchus, urine-holder.
Urĕter, from a Greek verb meaning 'I pass urine.'
Urethra, the canal by which urine is passed.
Uriniferous, urine-carrying.
Uterus, the womb or matrix.

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Utricle, a little womb or matrix.
Uvĕa, from *uva*, a bunch of grapes ; a cluster.
Uvula, a small bunch of grapes.

Vagina, a scabbard or sheath.
Vagus, strolling about, wandering, vagrant.
Vallecula, a little valley.
Vallum, a rampart.
Vas (pl. vasa), a vessel.
Velum, a curtain or veil.
Veneris, ' of Venus.'
Ventral, pertaining to the belly.
Ventricle or **Ventriculus,** a little belly.
Vermiform, like a worm.
Vertebra, from *verto*, ' I turn.'
Vertex, the top or crown of the head.
Veru, a dart, javelin, or spear.
Vesica, the urinary bladder.
Vesical, pertaining to the urinary bladder.
Vespertilio, a bat.
Vestigial, pertaining to a trace.
Vestigium, a trace or vestige.
Vibrissa, a stiff hair of the nostril.
Villus, shaggy hair ; a tuft of hair.
Vinculum, a band or bond.
Vitelline, pertaining to the yolk of an egg.
Vitellus, the yolk of an egg.
Vitreous, like glass, glassy.
Vola, the palm of the hand.
Volar, pertaining to the palm ; palmar.
Vomer, a ploughshare.
Vorticosæ, full of whirlpools. eddying, coiled.
Vulva, a wrapper or covering.

Xiphoid, like a sword.

Zygōma, a yoke.

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